

Microphysical modeling of TTL dehydration processes during Fall 2011 ATTREX deployment



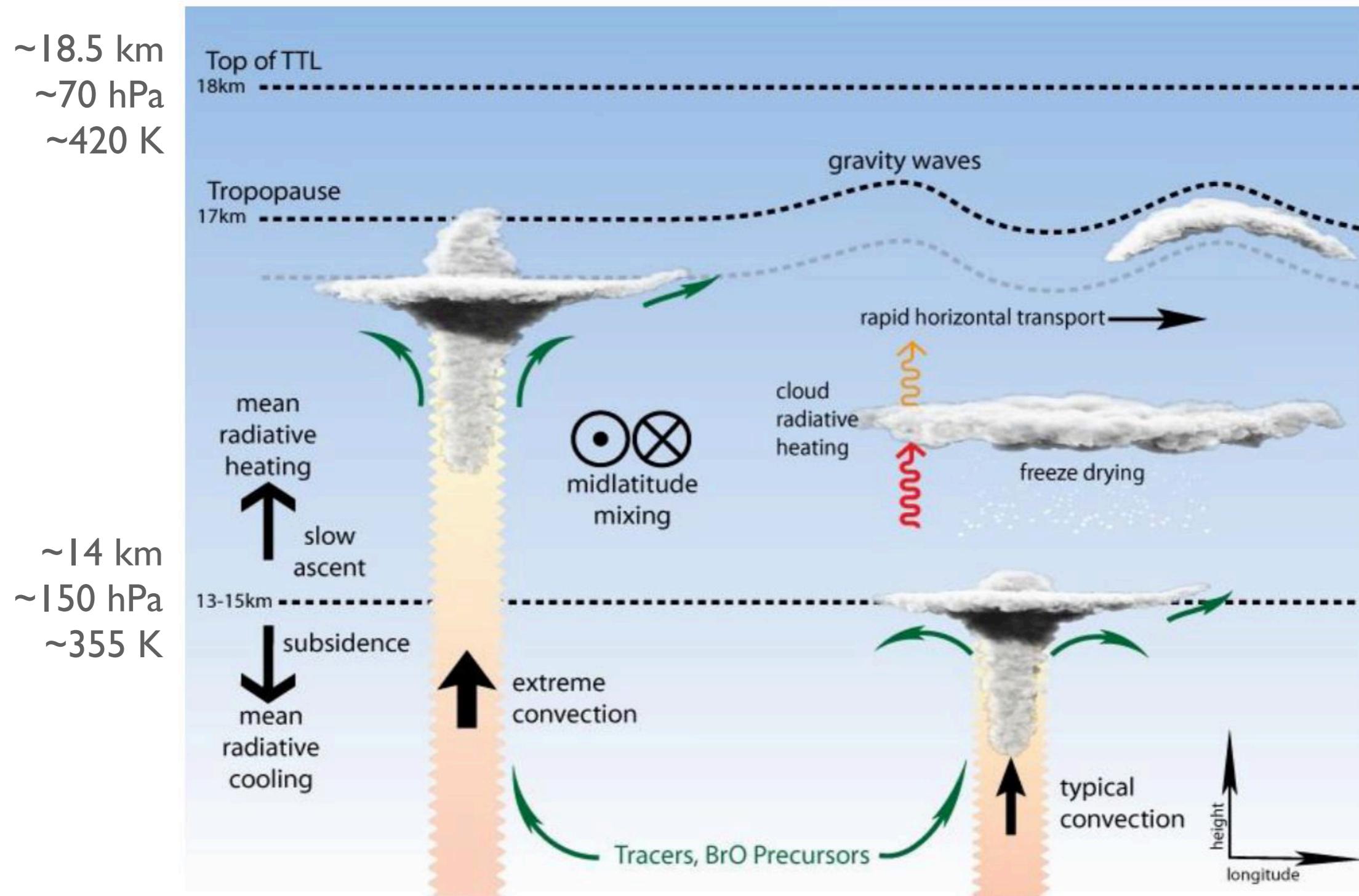
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NASA Ames Research Center



♥ Many thanks to the DLH and MMS teams for the data!

Research Goal

To investigate the dynamical and microphysical processes that control water vapor concentrations in the TTL



Methods

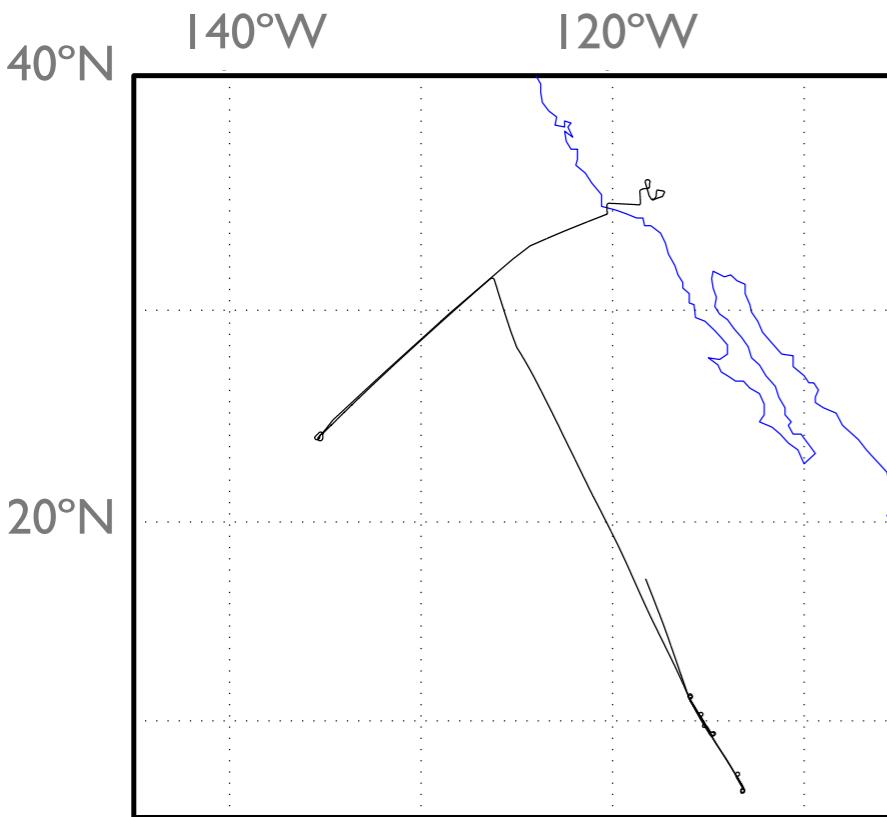
1. Develop a model capability of simulating the observed TTL water vapor concentrations in a case study
 - backward trajectories of sampled air parcels
 - cloud microphysical model simulations
2. Apply the tools and techniques for a global study

Methods

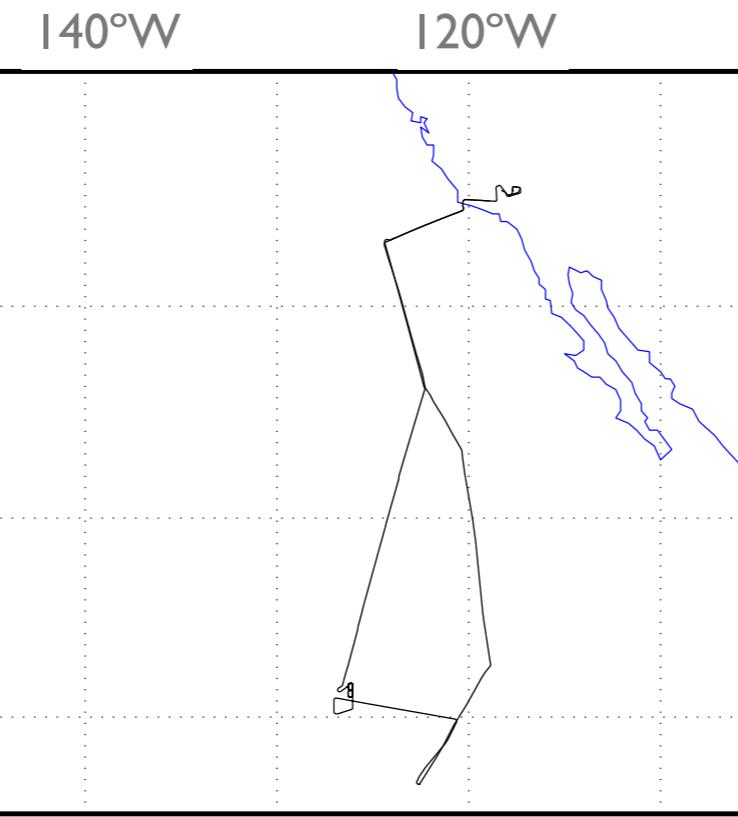
- I. Develop a model capability of simulating the observed TTL water vapor concentrations in a case study ➔ **ATTREX Fall 2011 flights**
 - backward trajectories of sampled air parcels
 - cloud microphysical model simulations
2. Apply the tools and techniques for a global study

Fall 2011 Flight Tracks

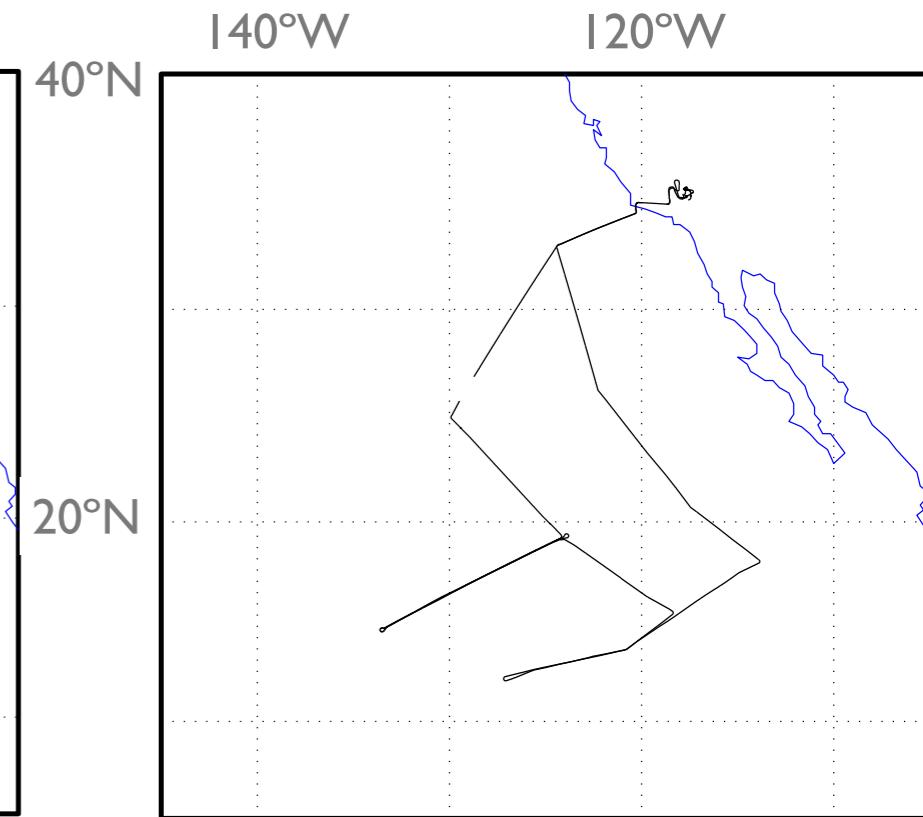
28-29 Oct
(18-39 UTC)



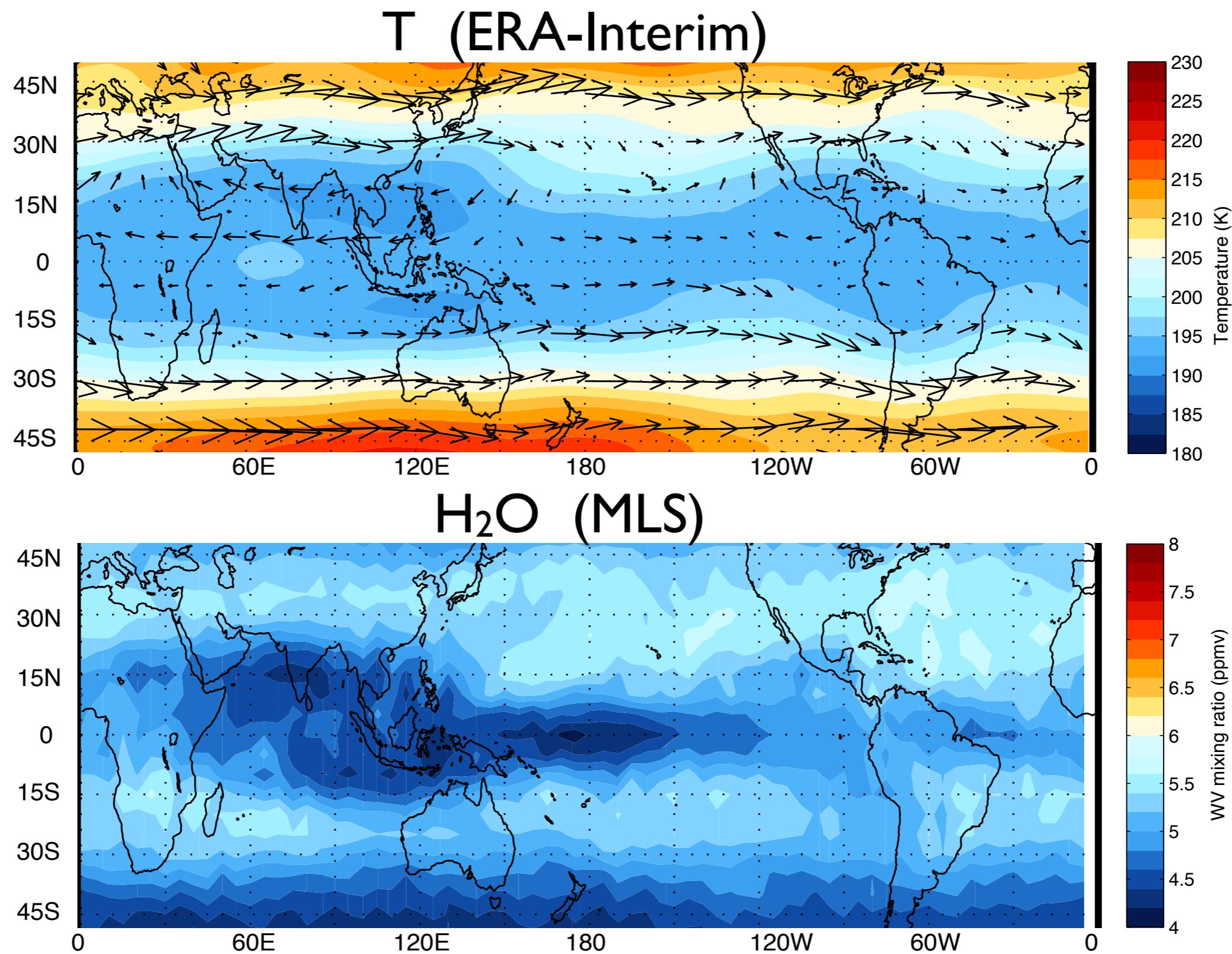
5-6 Nov
(17-34 UTC)



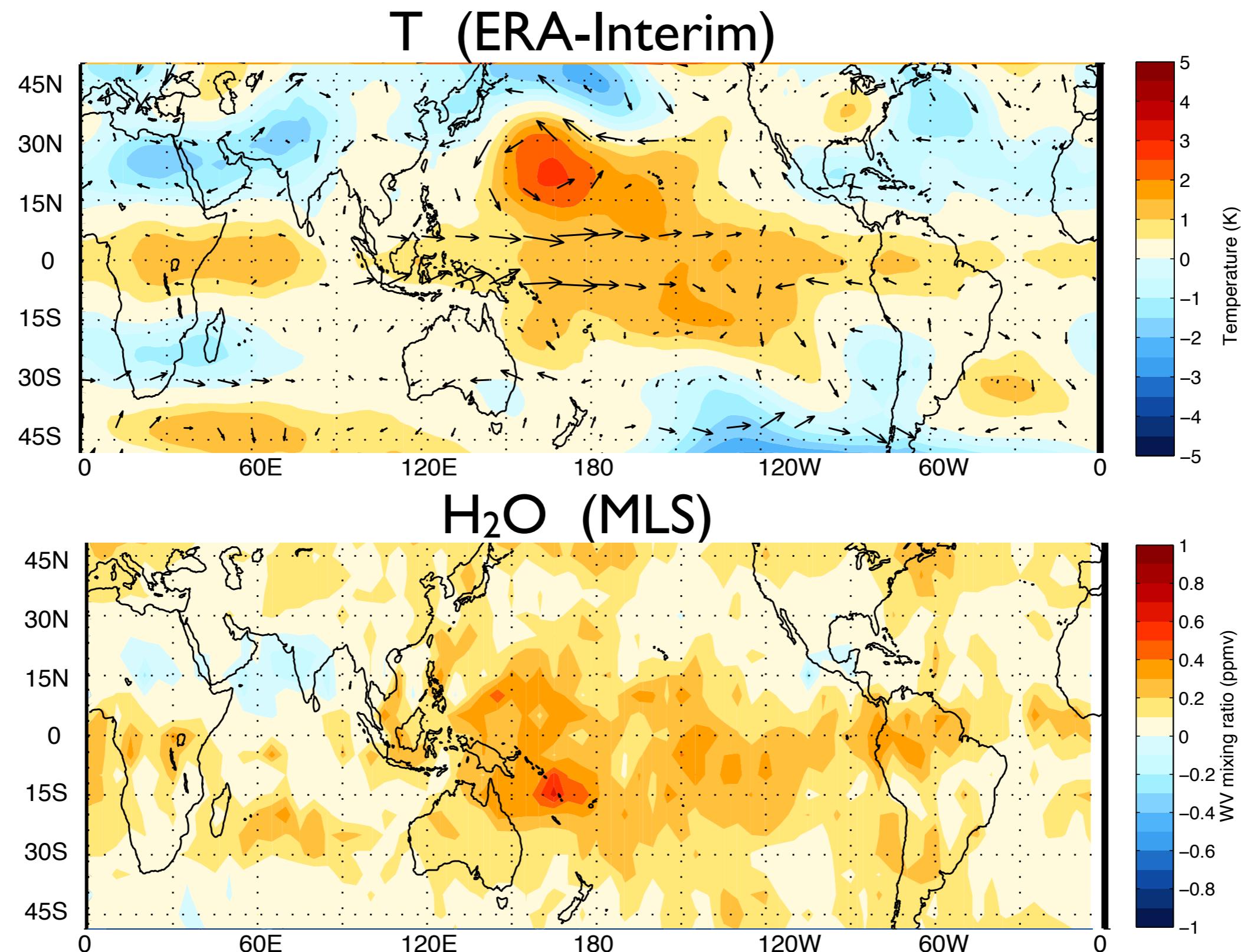
9-10 Nov
(18-41 UTC)



Sep-Oct-Nov 2011 at 100 hPa

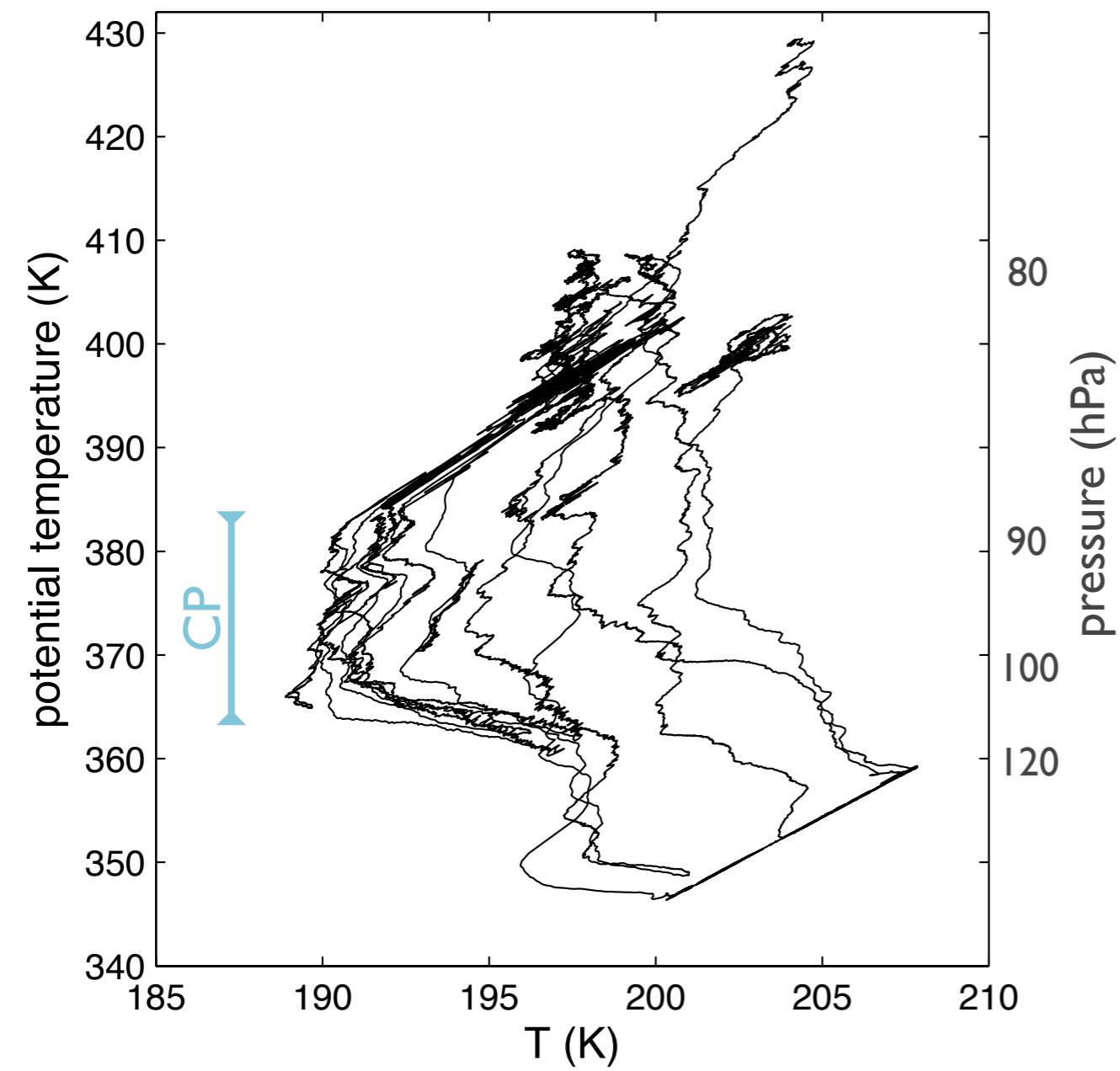


Sep-Oct-Nov 2011 at 100 hPa



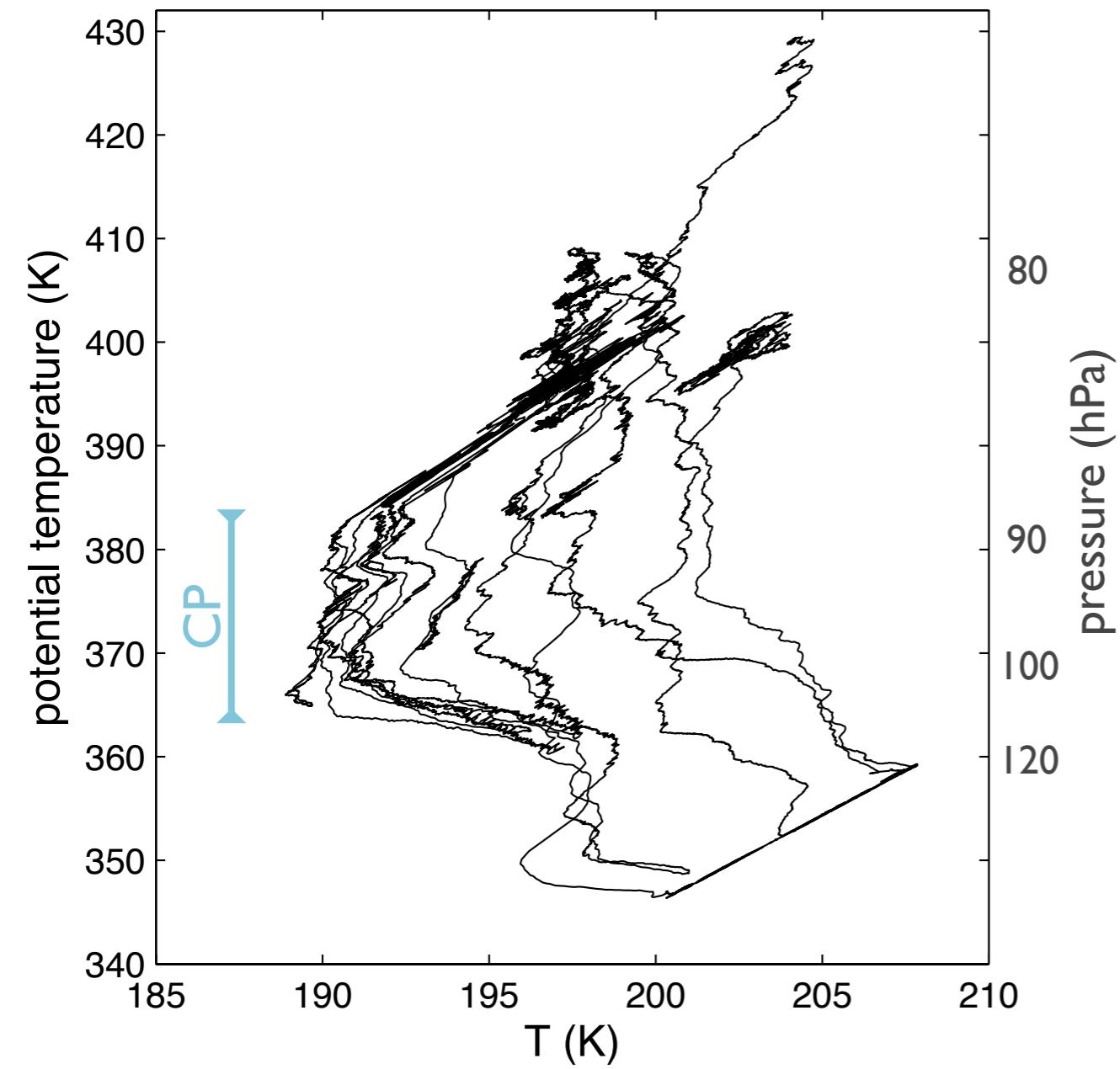
5-6 Nov 2011 Flight

T (MMS)

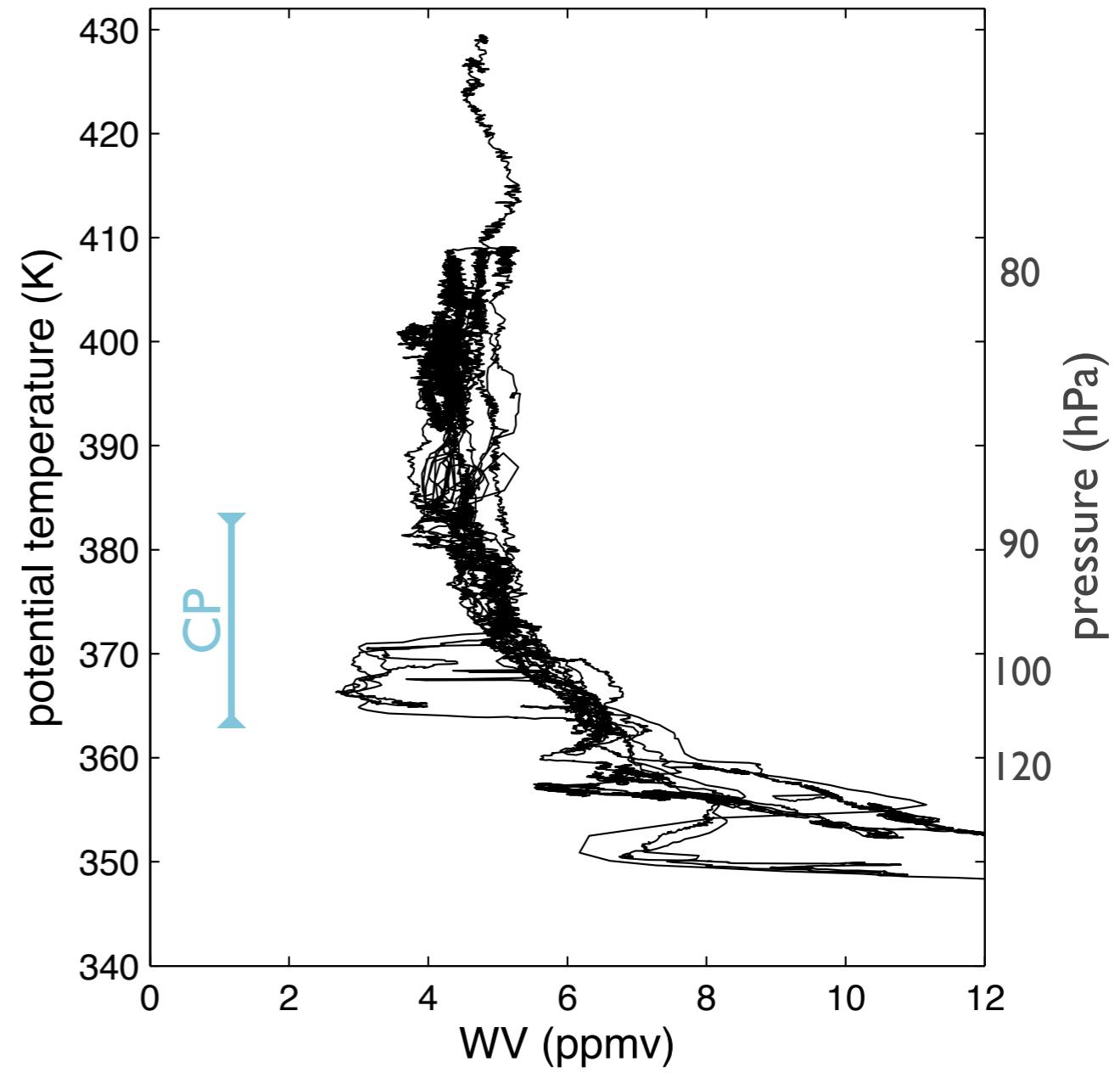


5-6 Nov 2011 Flight

T (MMS)



H₂O (DLH)

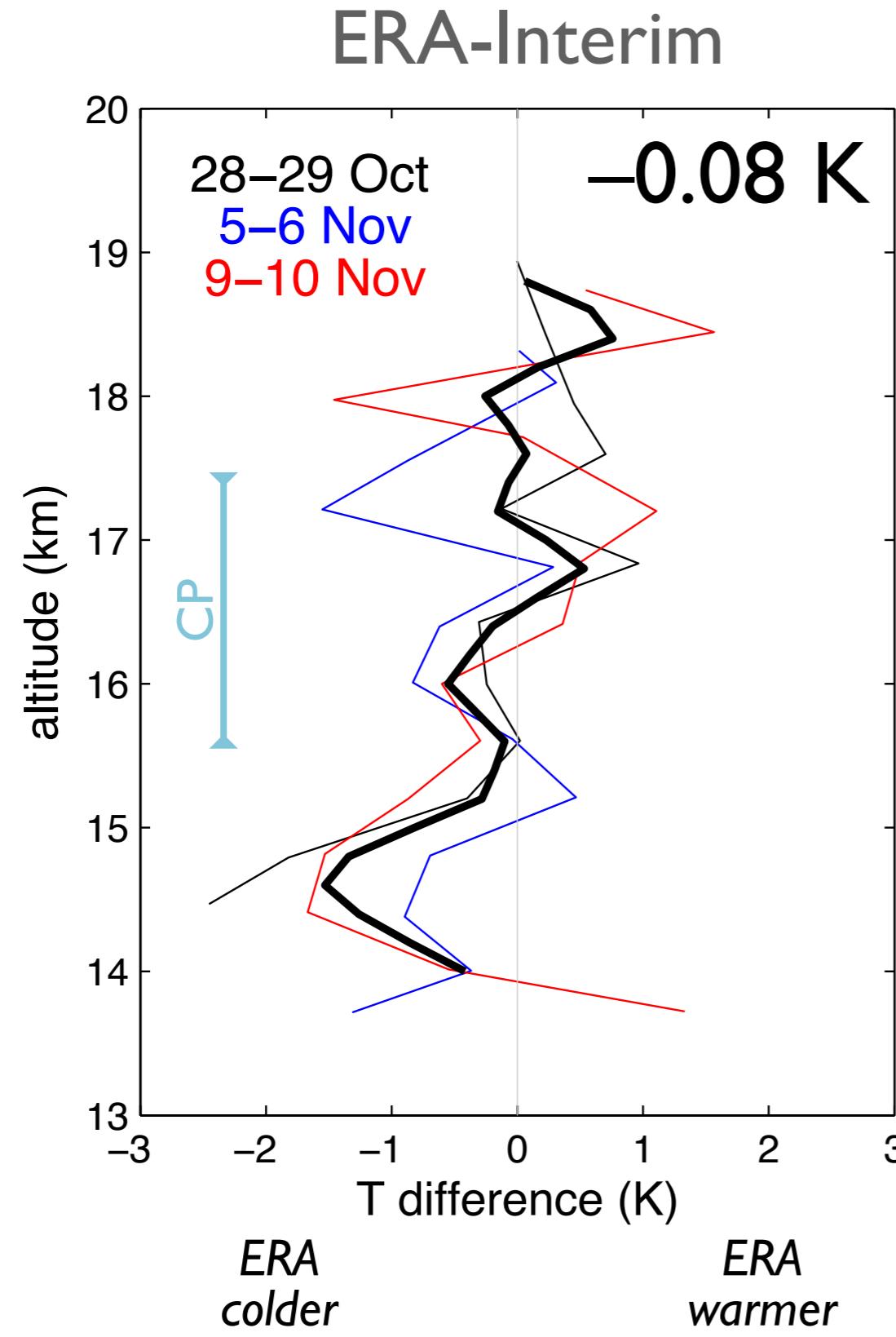


Trajectory analysis

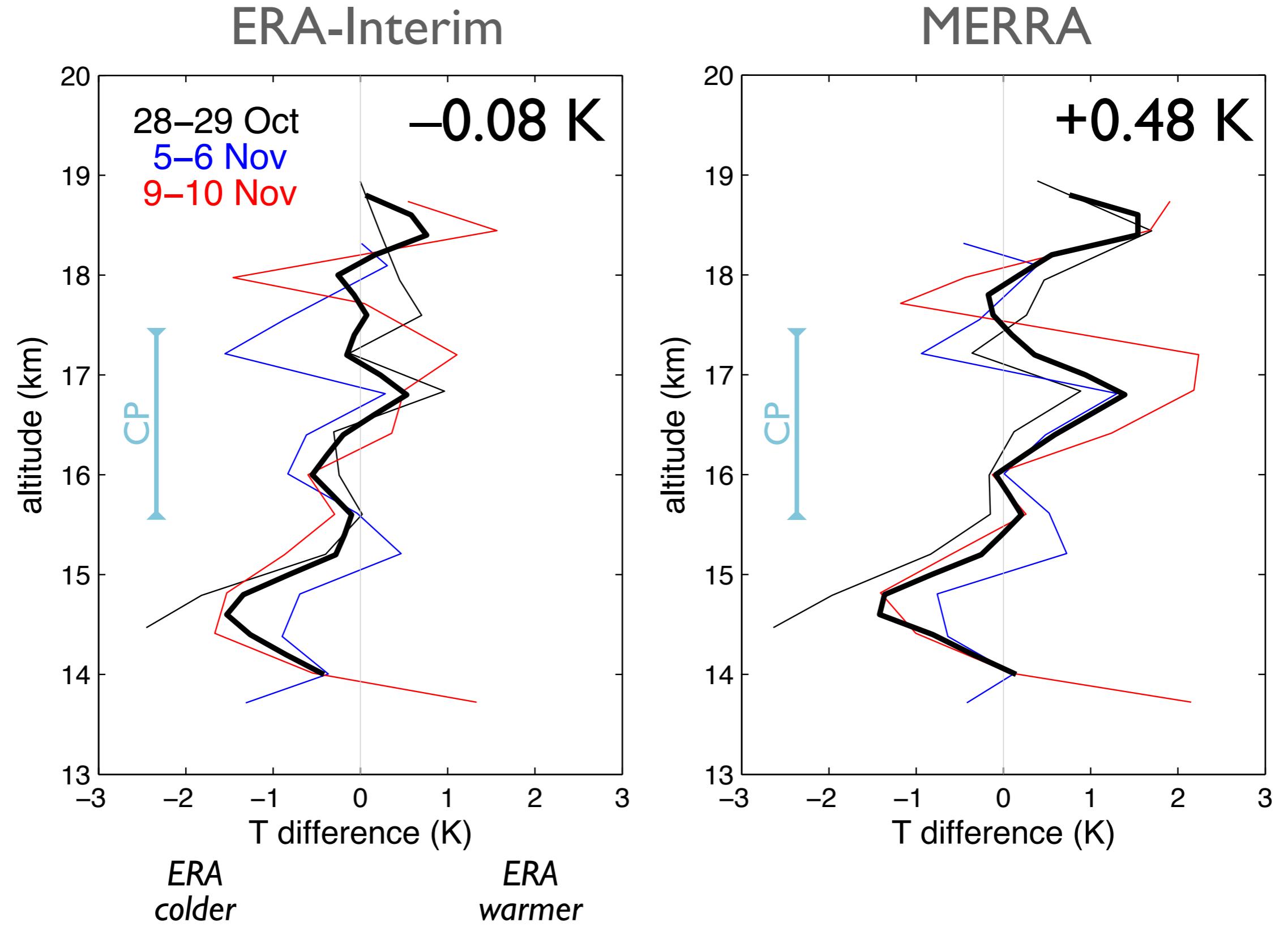
40-day diabatic backward trajectories from the times and locations along the flight tracks

- ERA-Interim wind and T
- 2006-07 Oct-Nov mean diabatic heating rates in the tropics (*Yang et al. 2010*)

T difference: reanalysis – aircraft

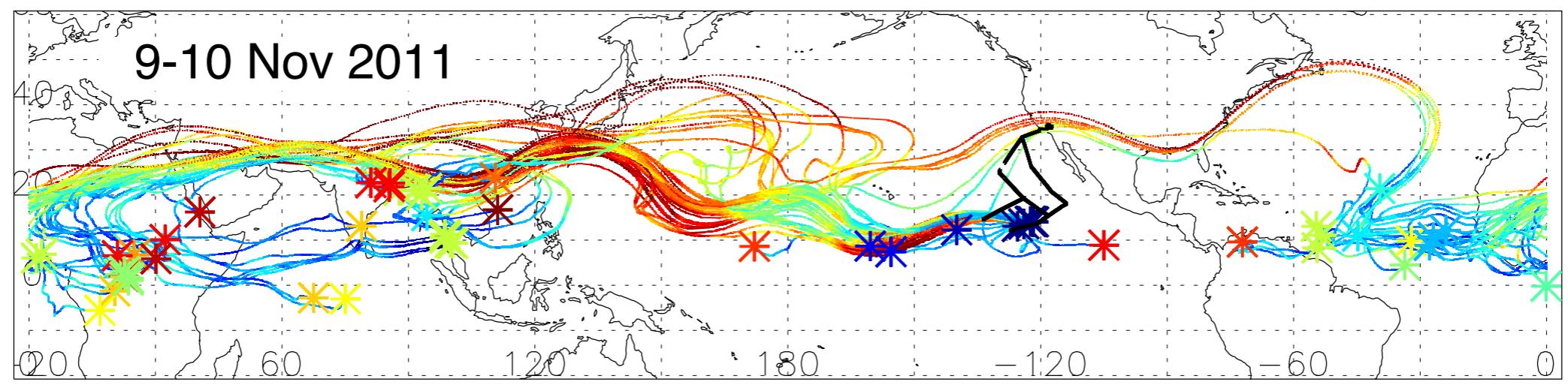
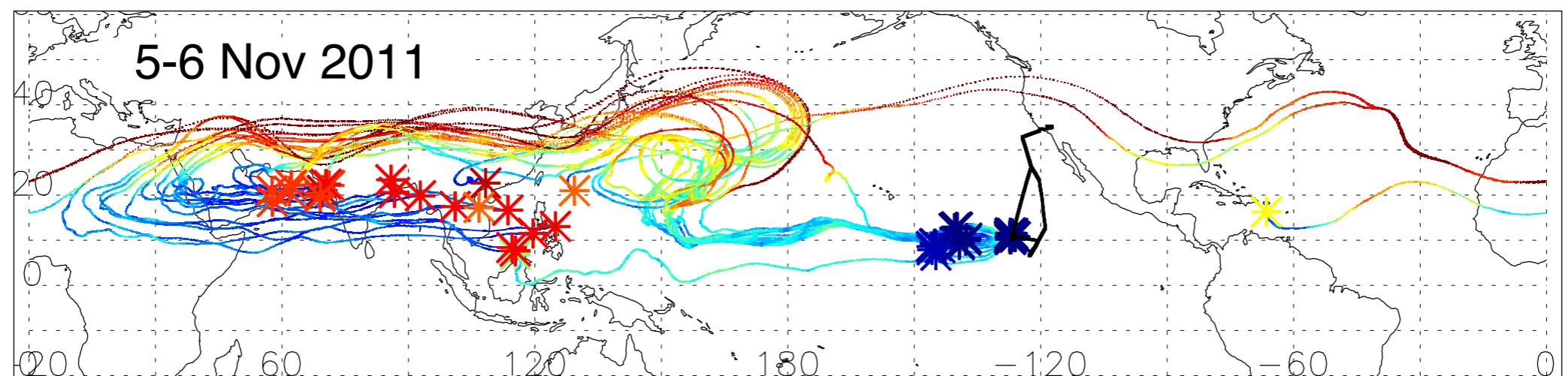
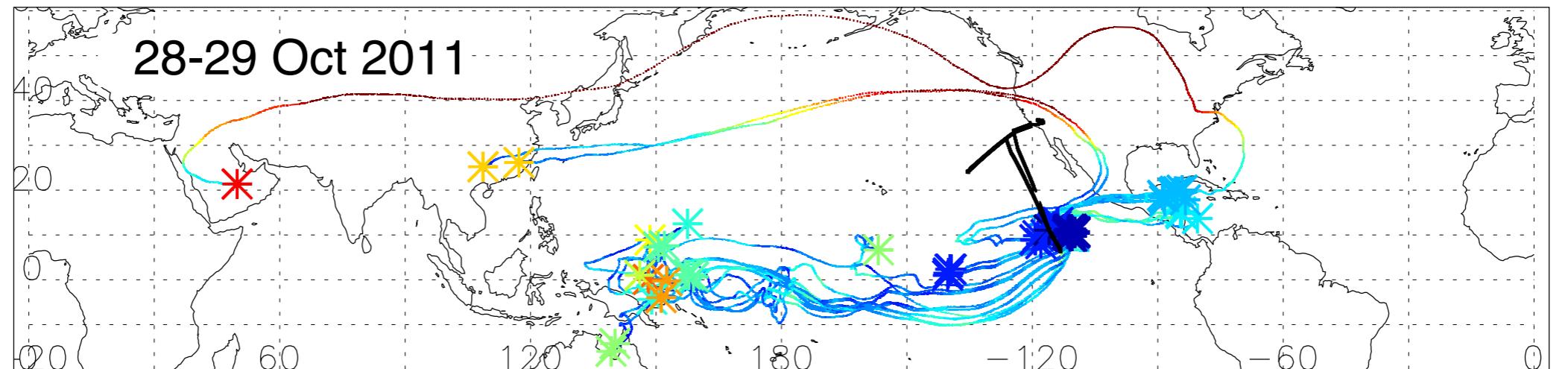


T difference: reanalysis – aircraft



Backward trajectory temperatures

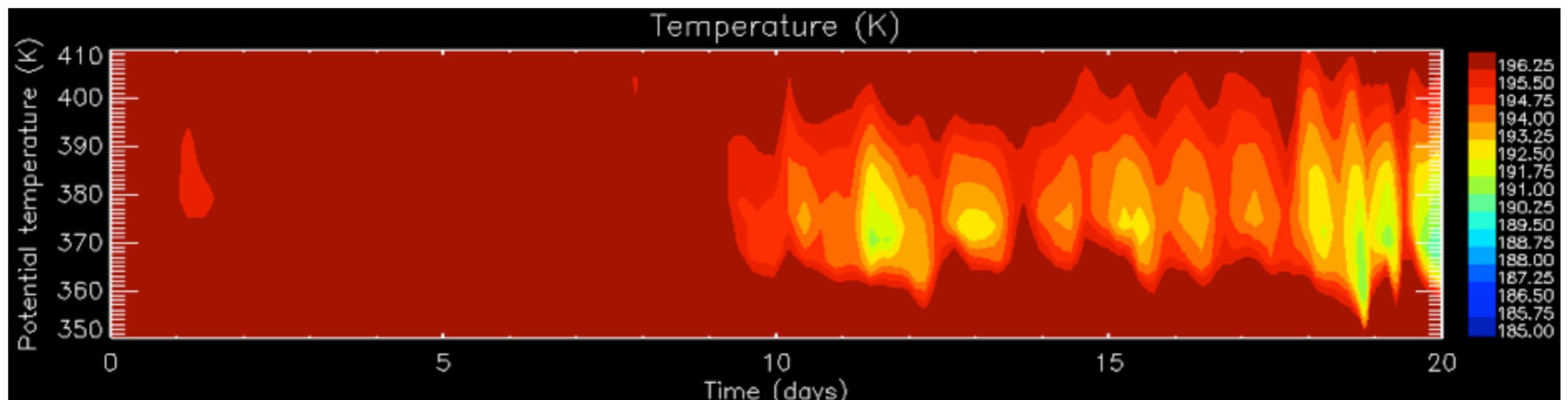
* location of min T along each trajectory



188 190 192 194 196 198 200 202 204 206 208 0 4 8 12 16 20 24 28 32 36 40 (K) (day)

1D semi-Lagrangian cloud model

Simulates ice nucleation, deposition growth, ice crystal sedimentation and vertical advection of ice crystals and water vapor along a time-height “curtain” of temperature for a given backward trajectory (*Jensen and Pfister JGR 2004*)

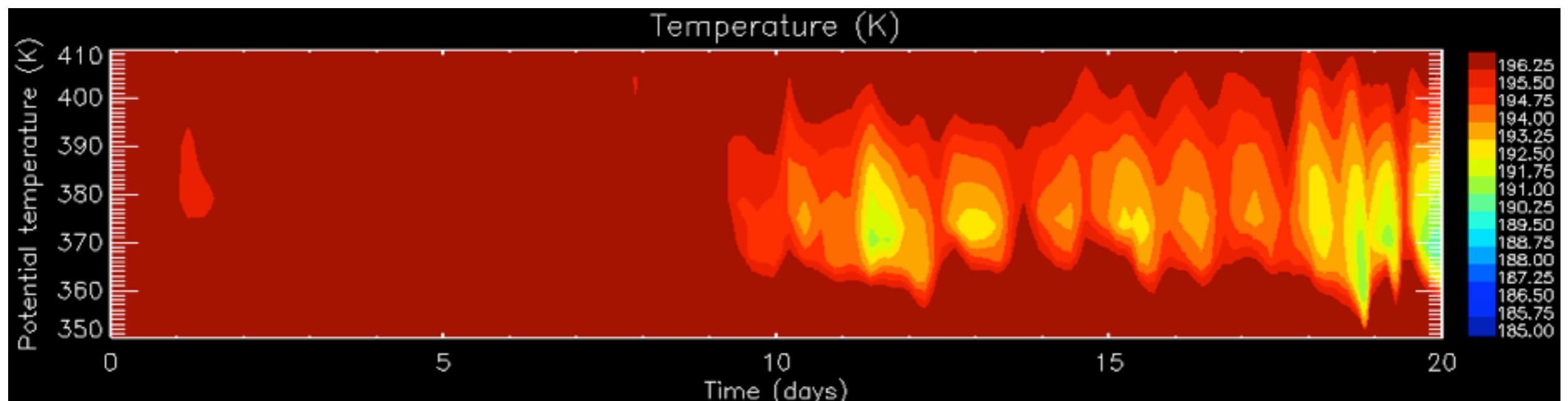


↑
–20 days before
(trajectory location
at earliest time)

↑
flight track
location and time

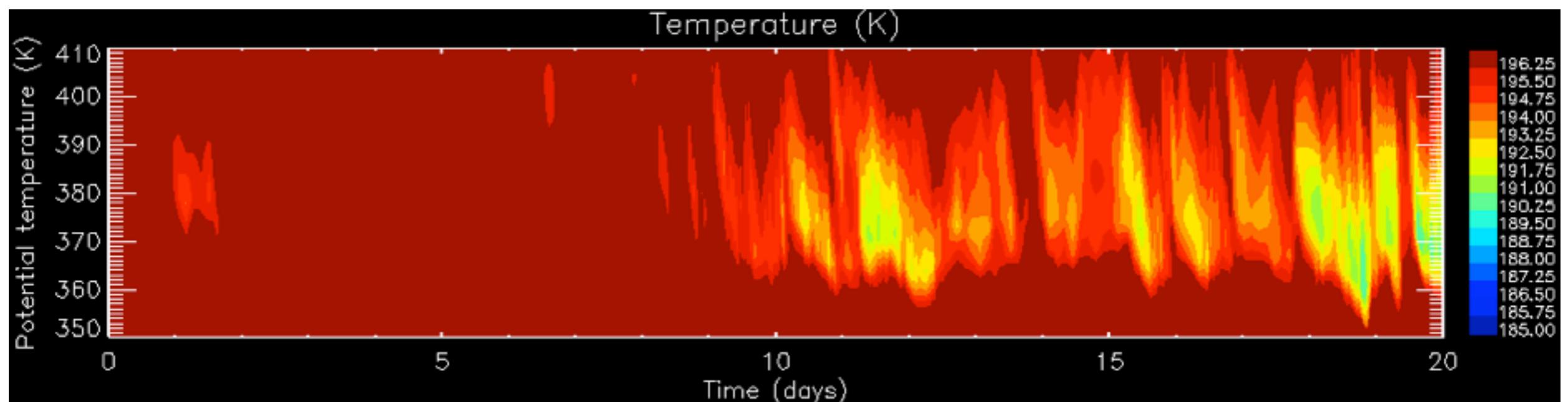
1D semi-Lagrangian cloud model

- * “wave”: temperatures perturbed by subgrid-scale gravity waves
- * “no micro”: remove all water vapor in excess of saturation
- * “convection”: saturate up to the highest cloud top altitude



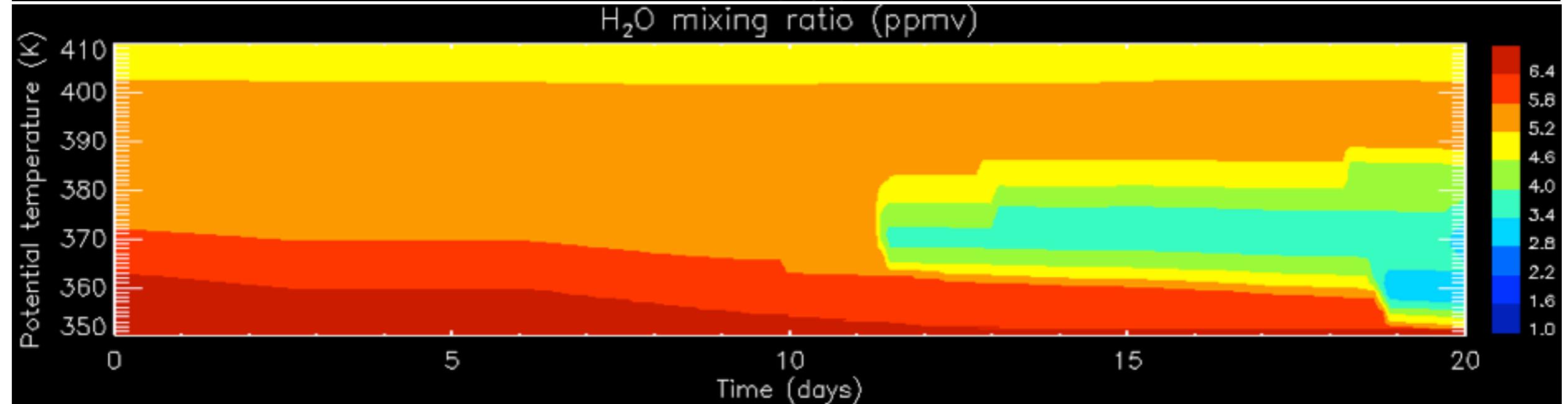
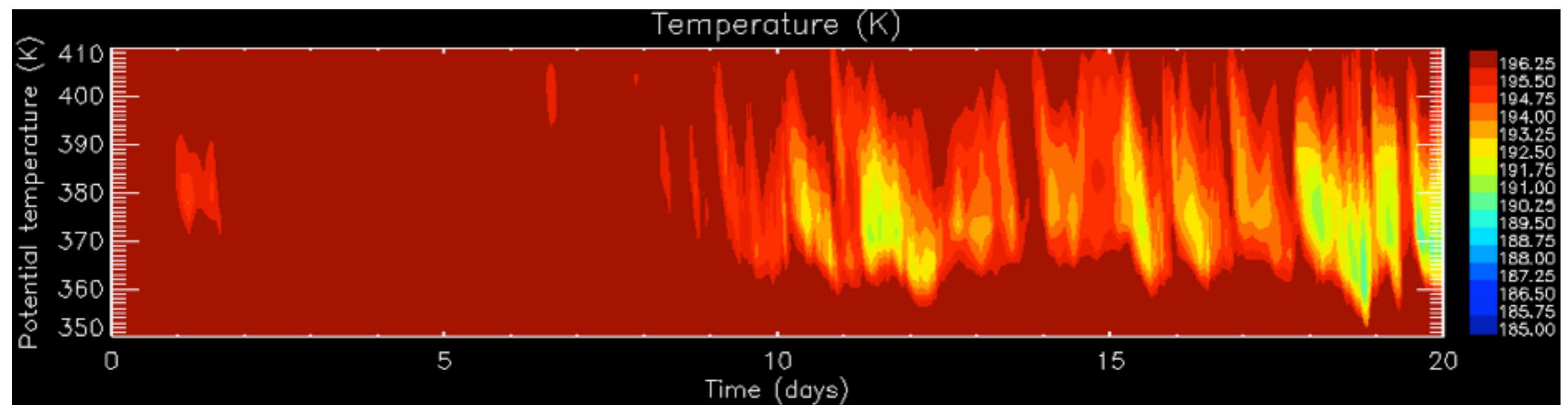
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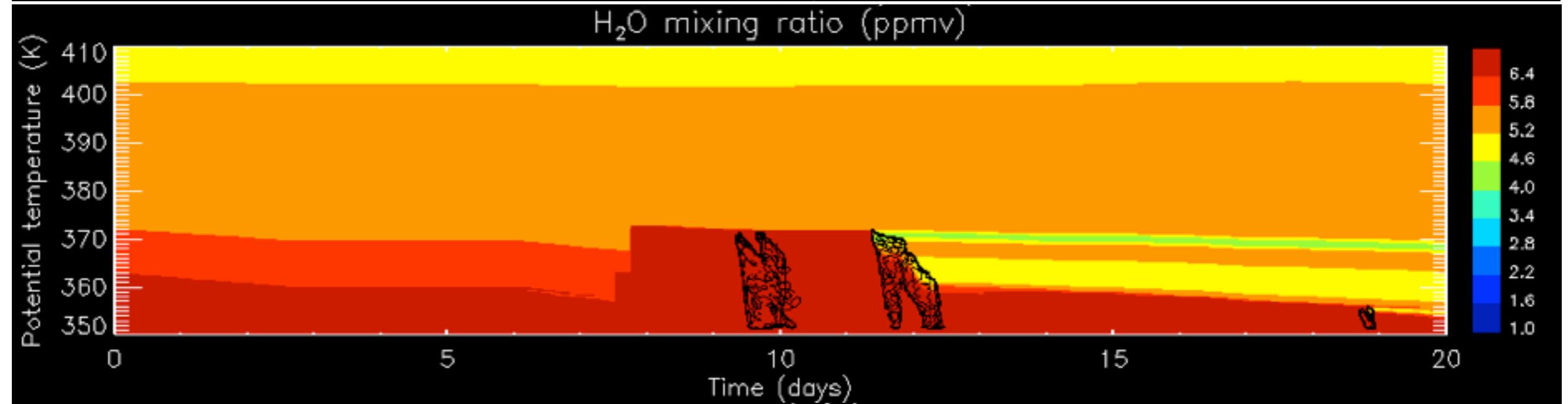
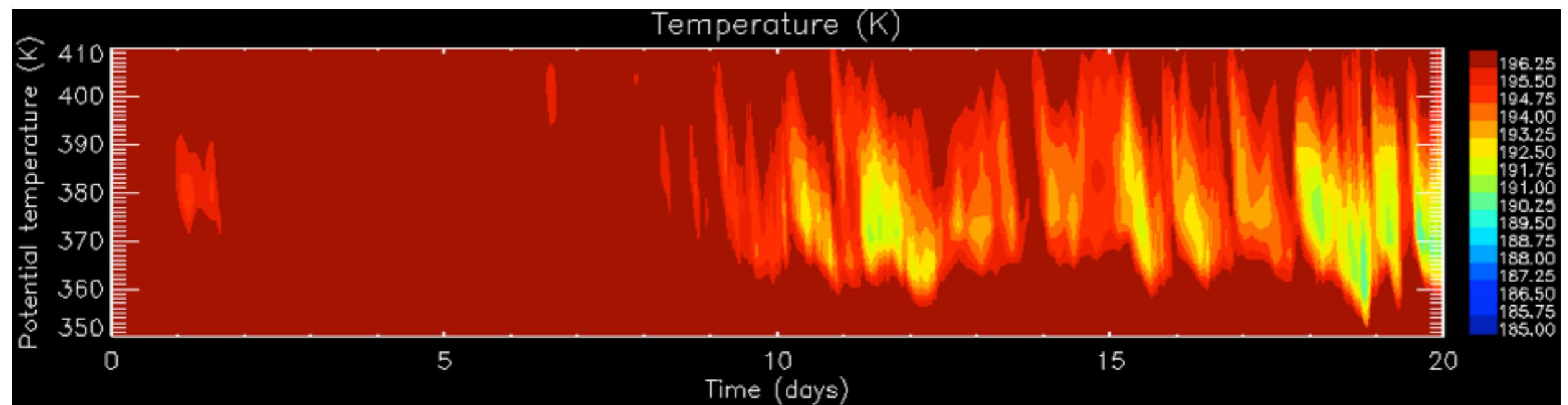
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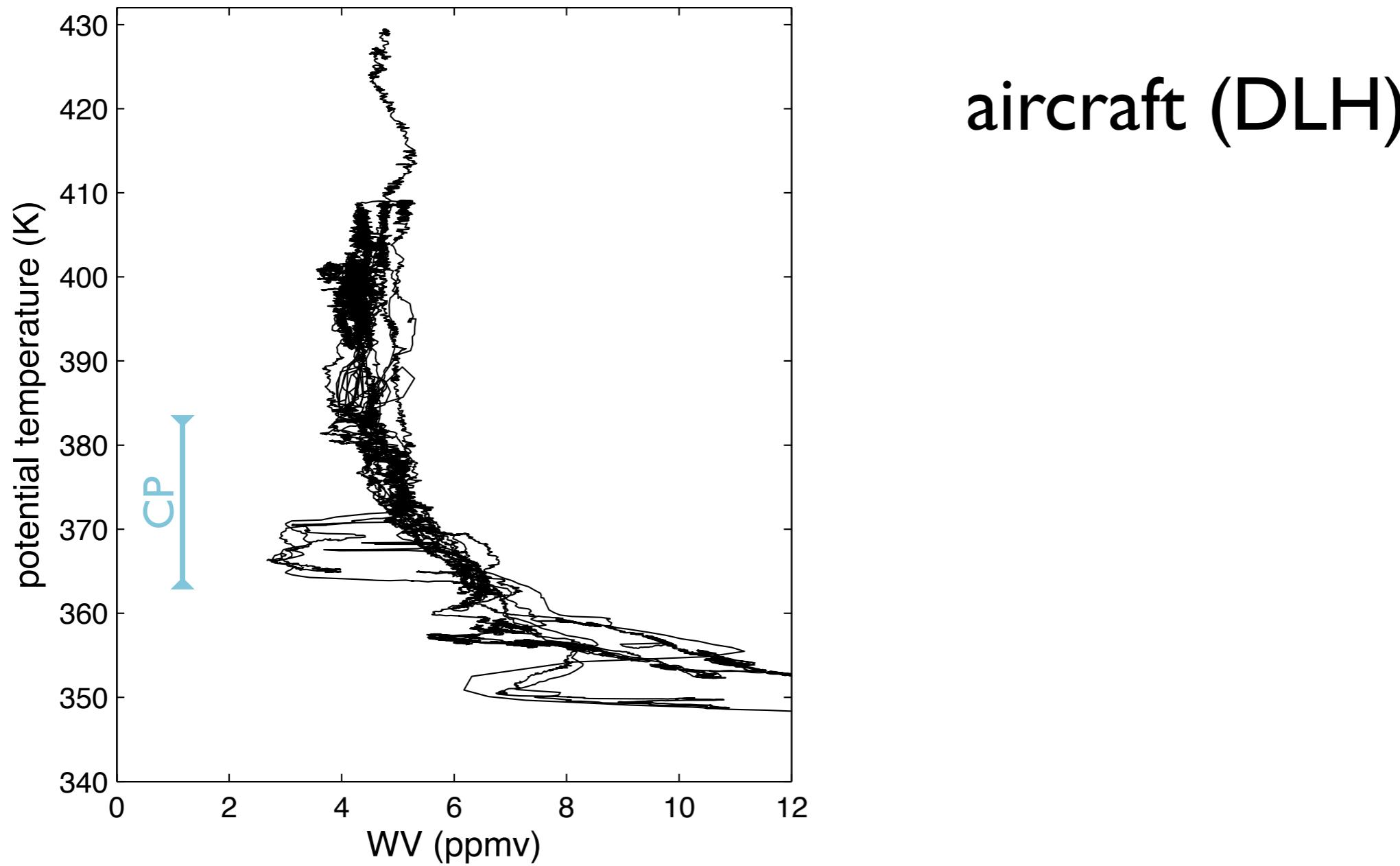
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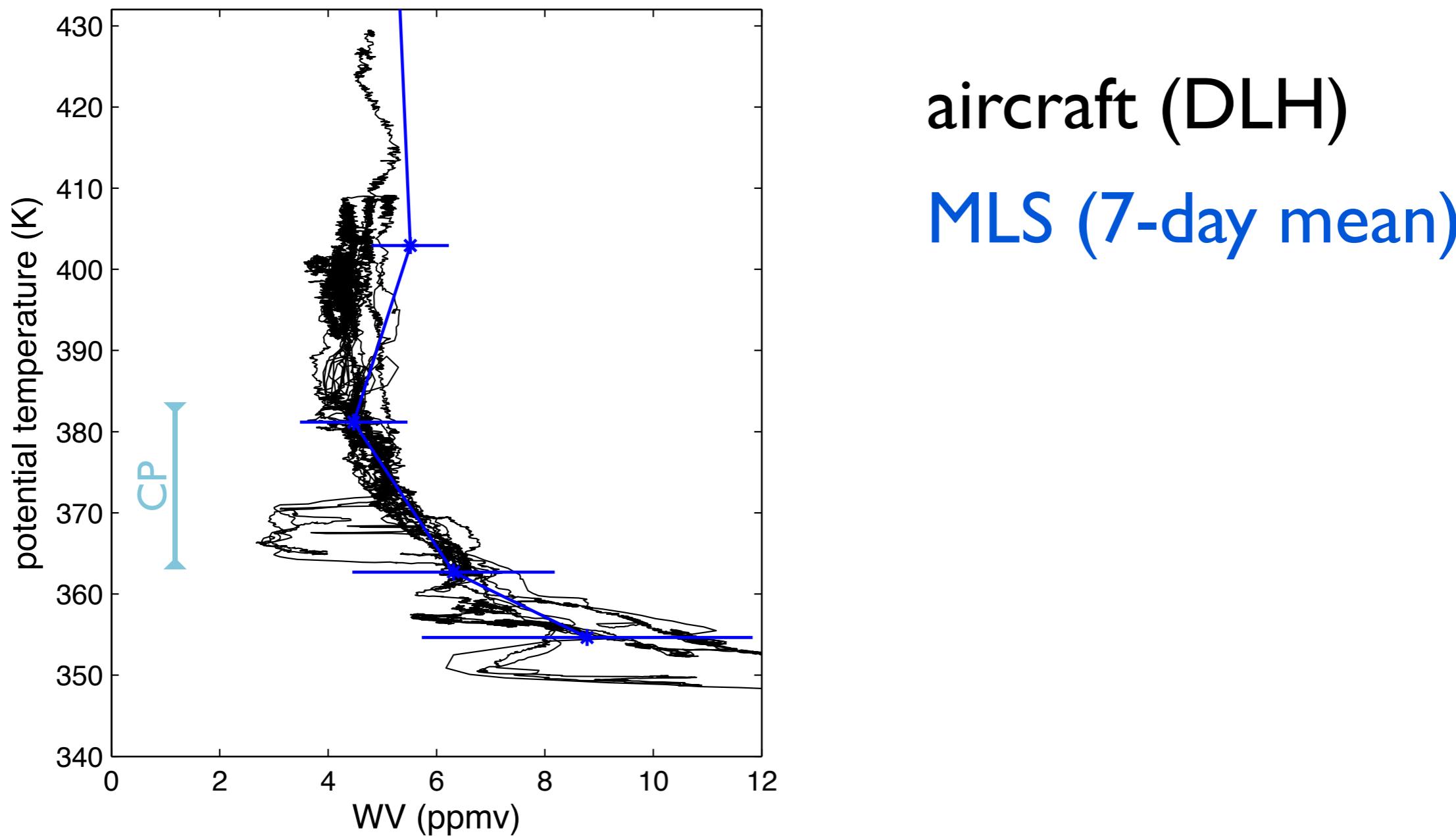
Vertical profile of H₂O

(5-6 Nov 2011)



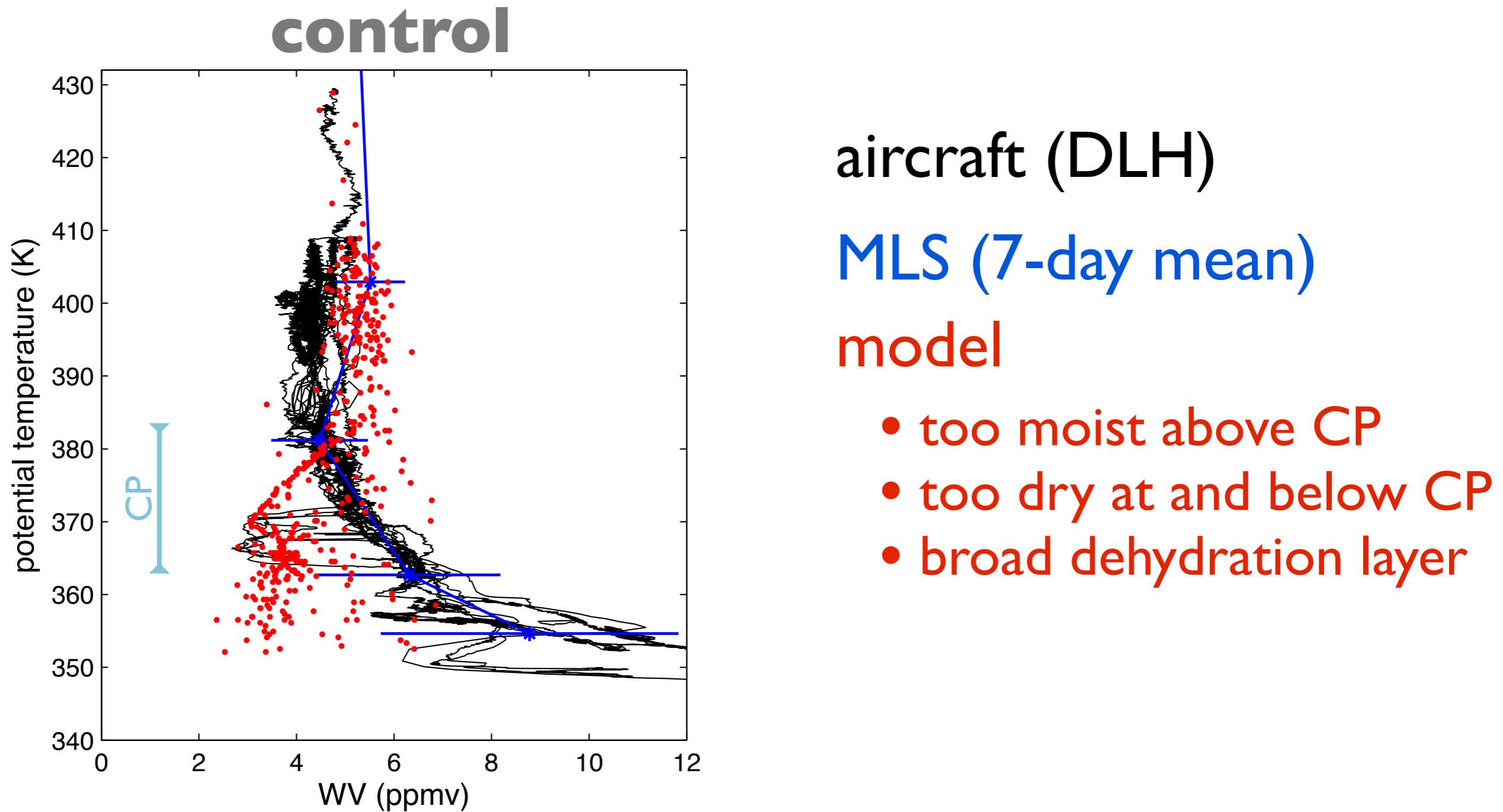
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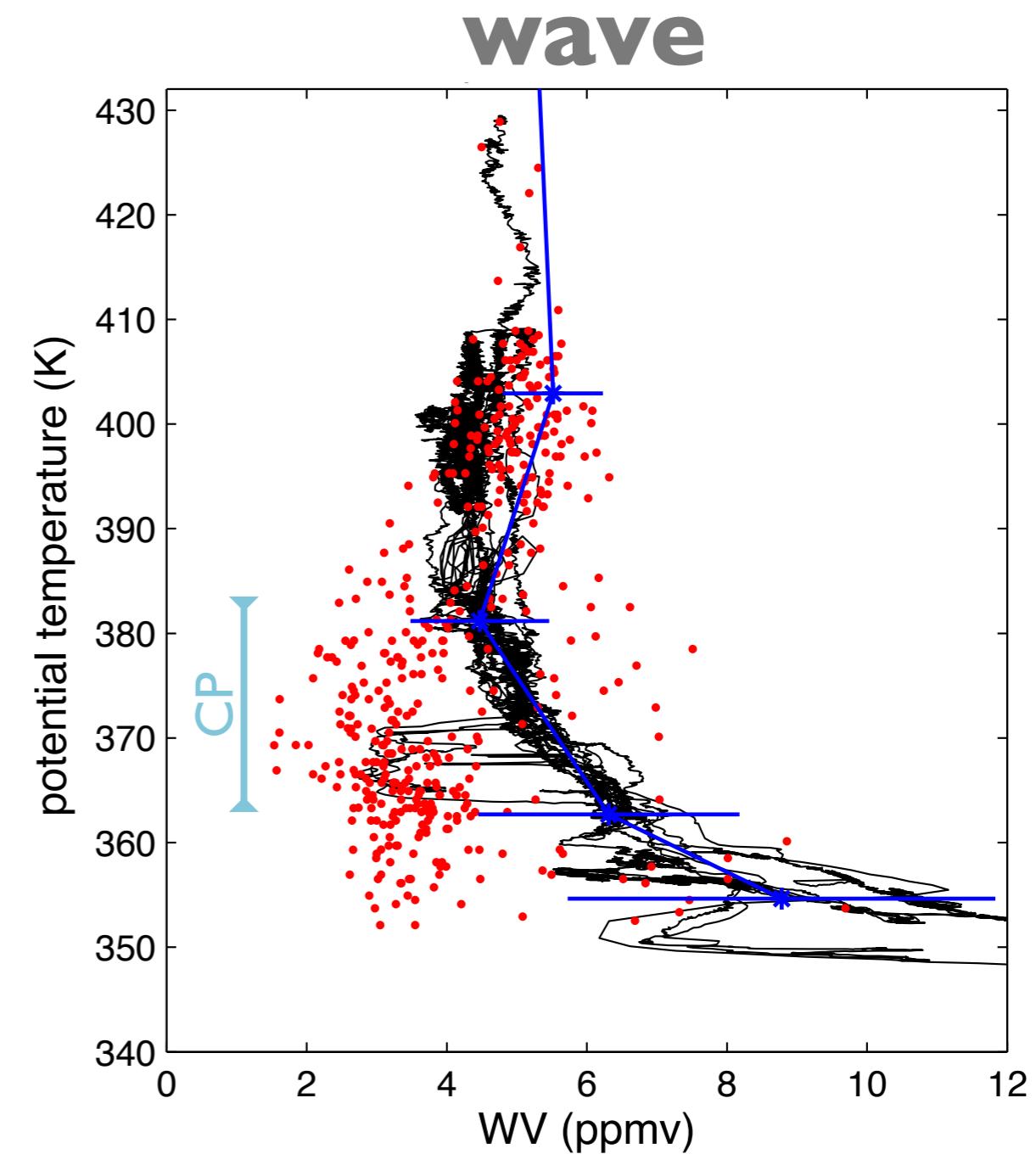
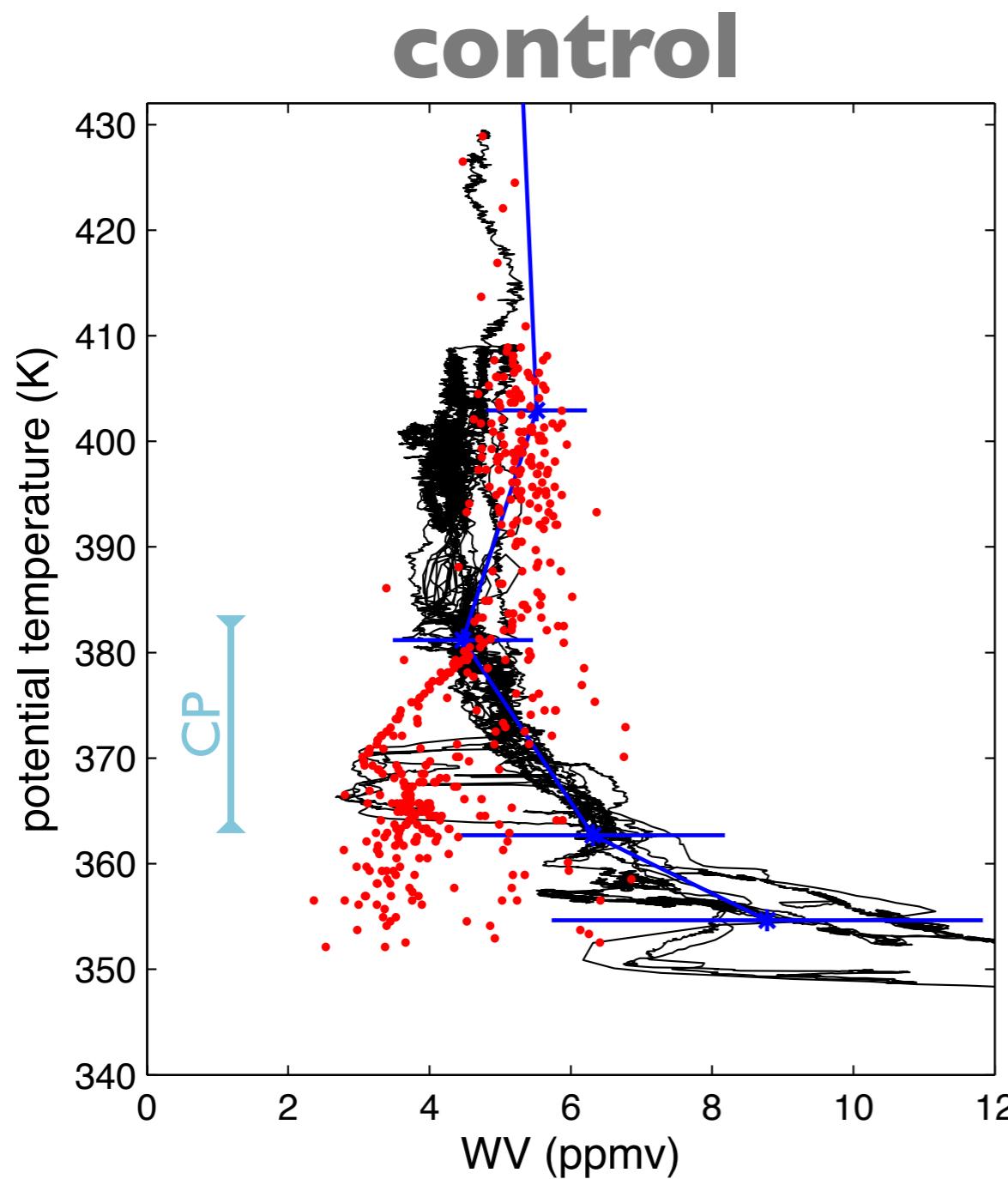
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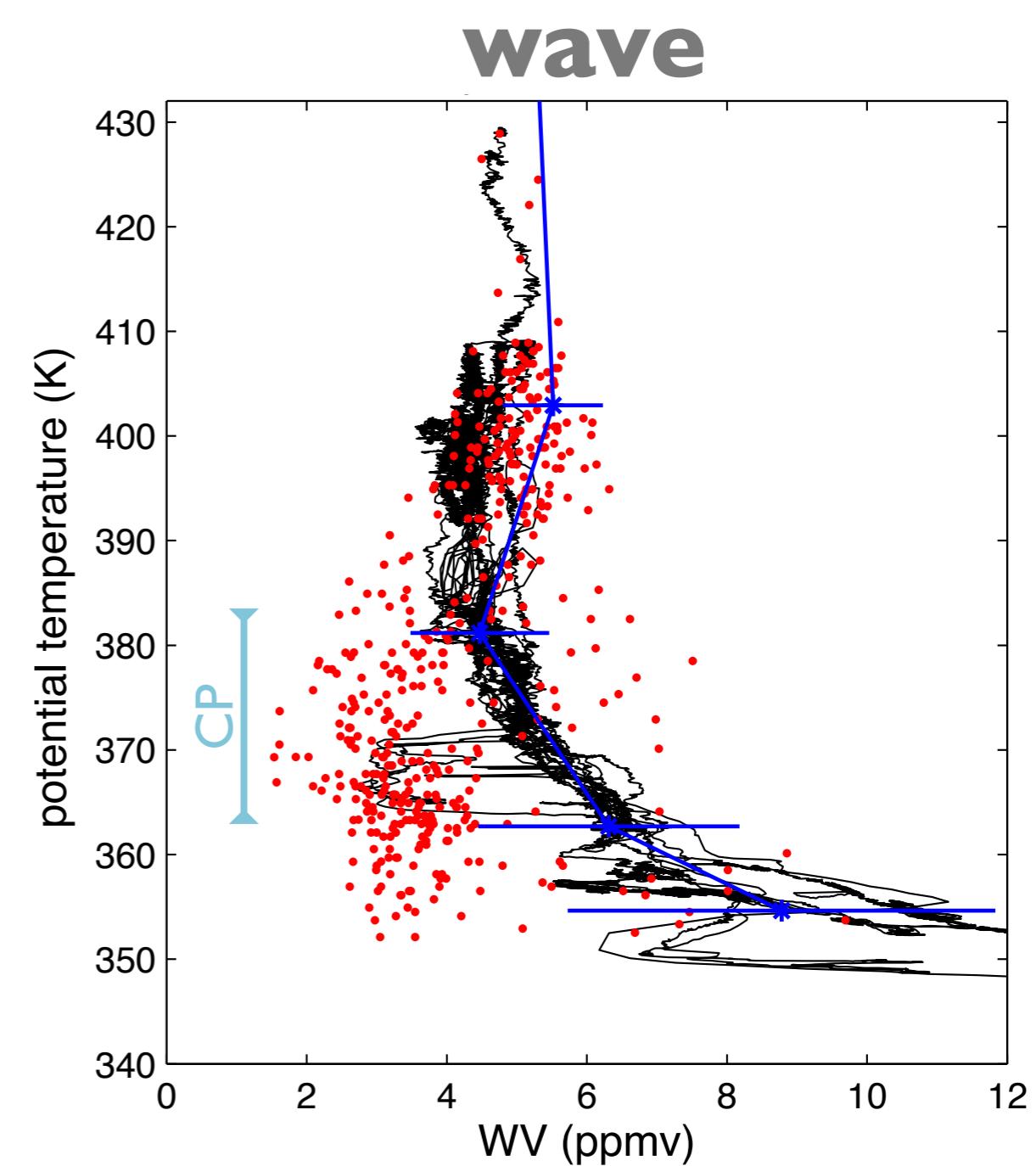
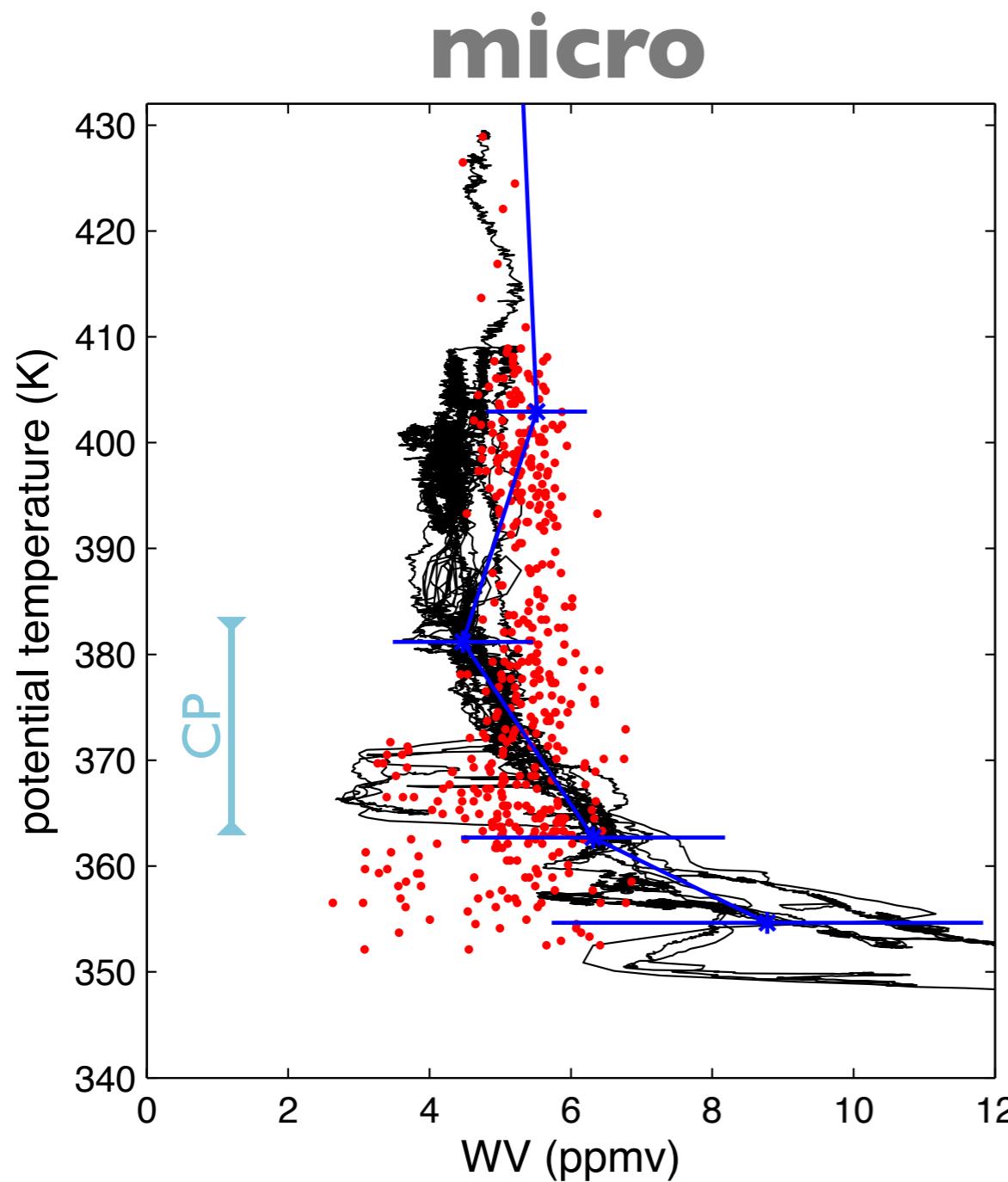
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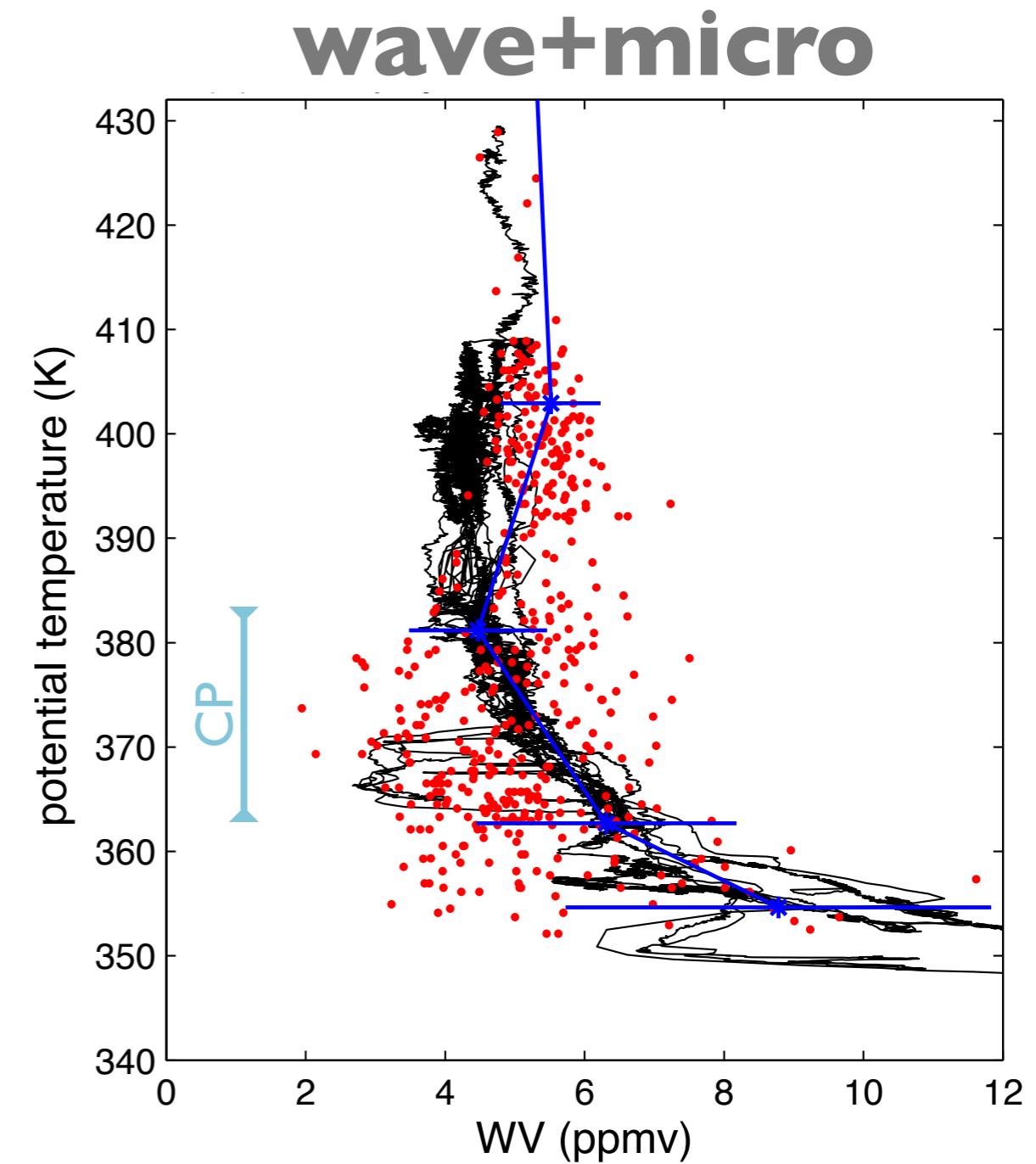
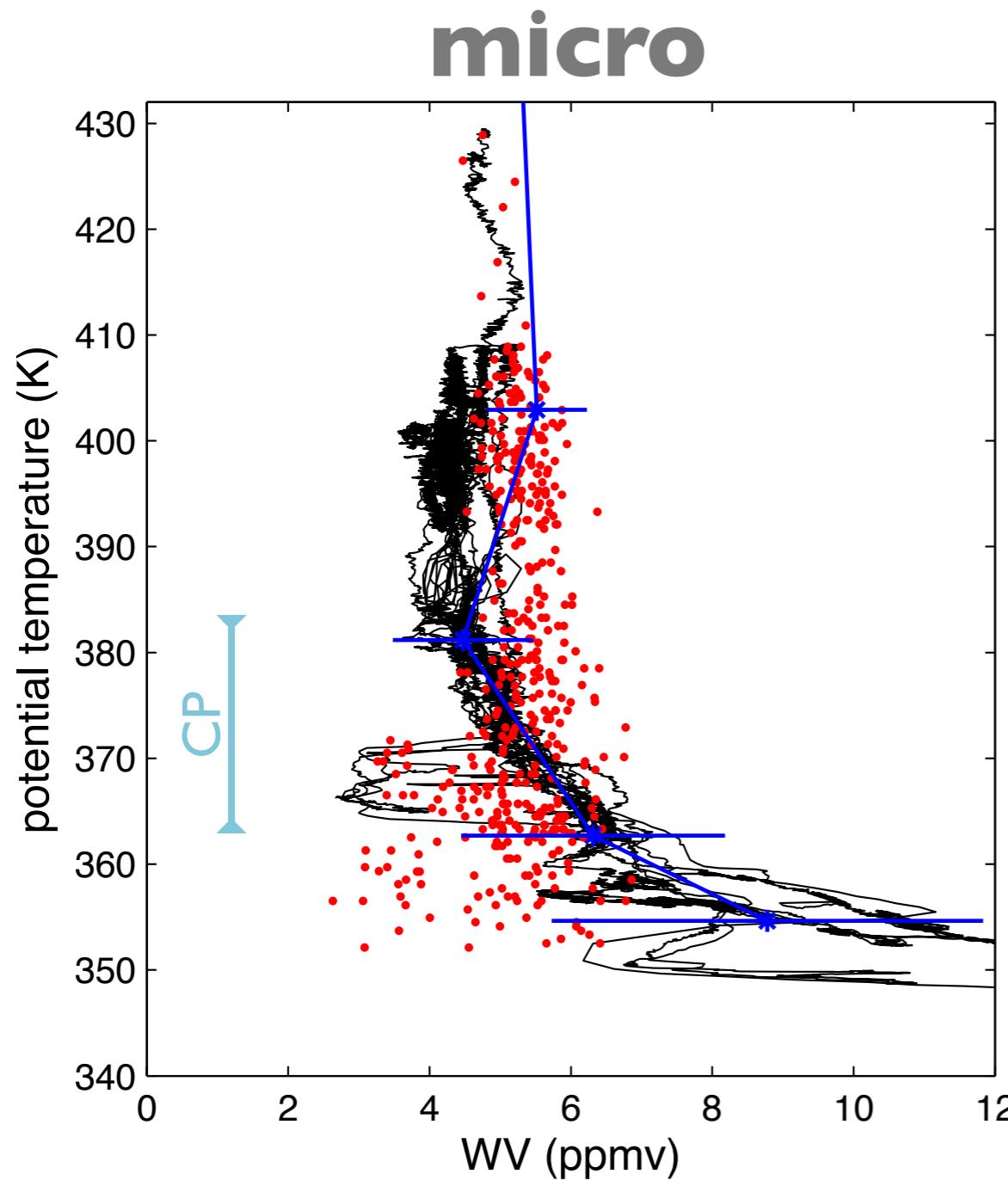
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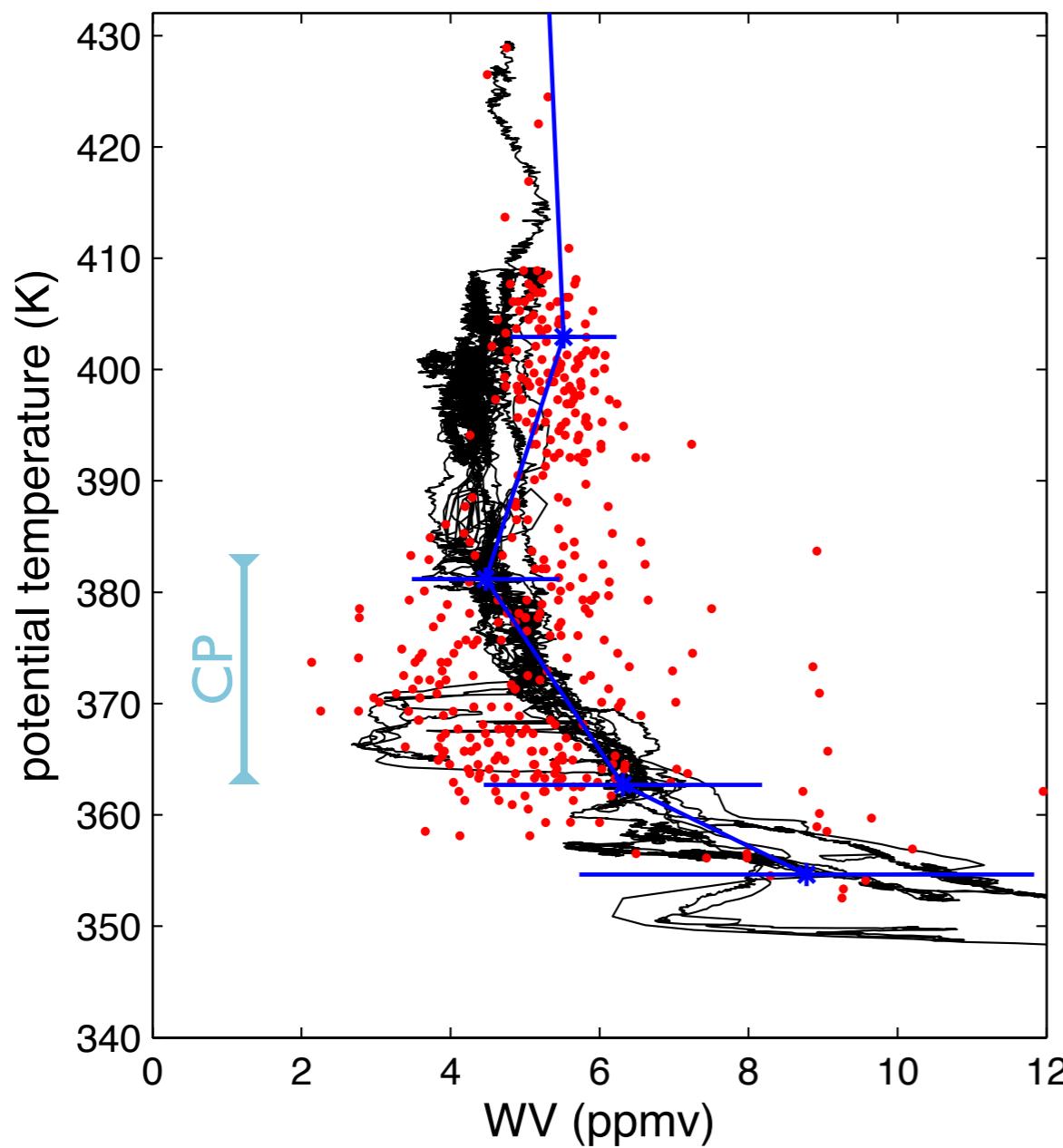
(5-6 Nov 2011)



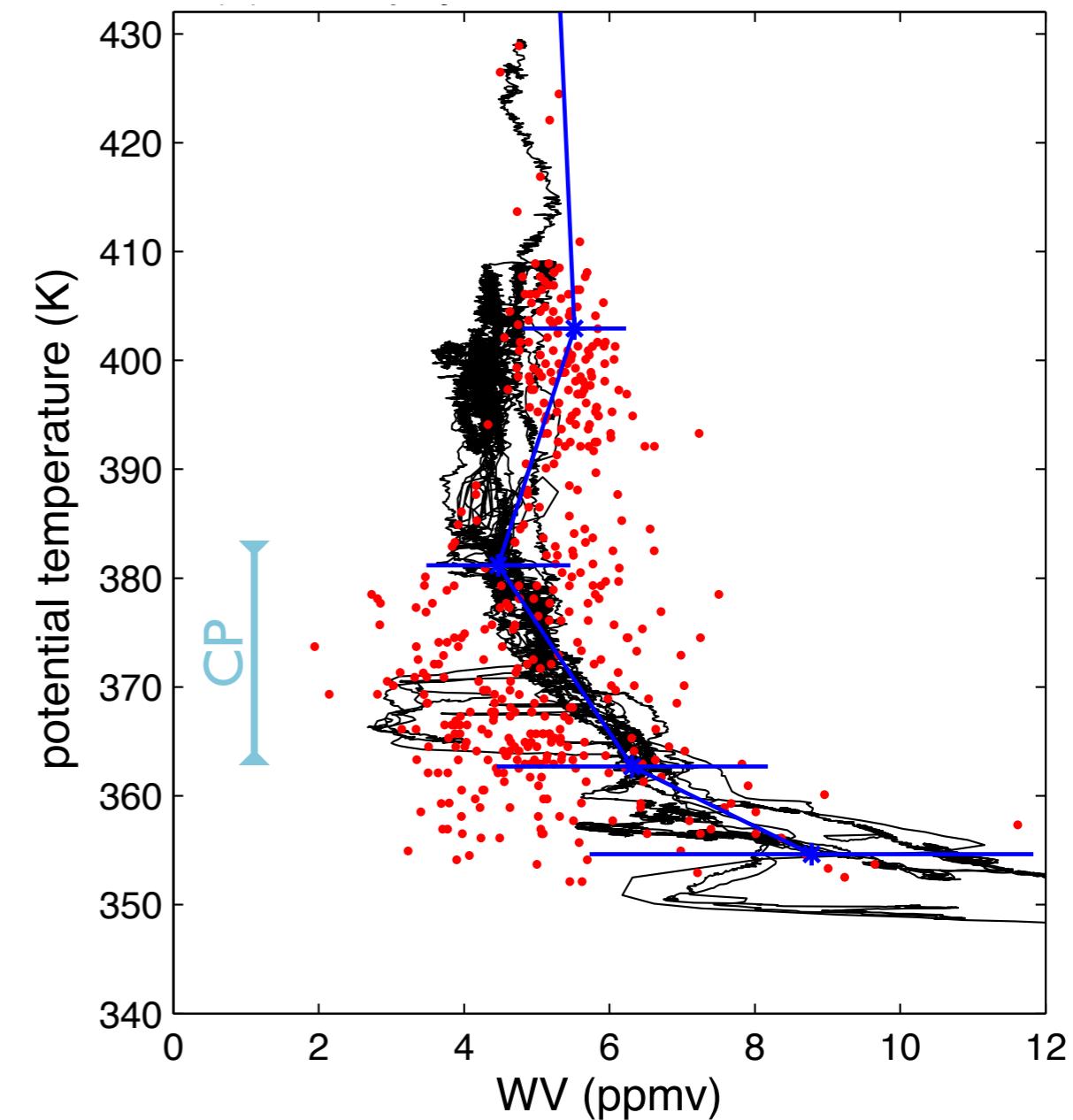
Vertical profile of H₂O

(5-6 Nov 2011)

wave+micro+conv

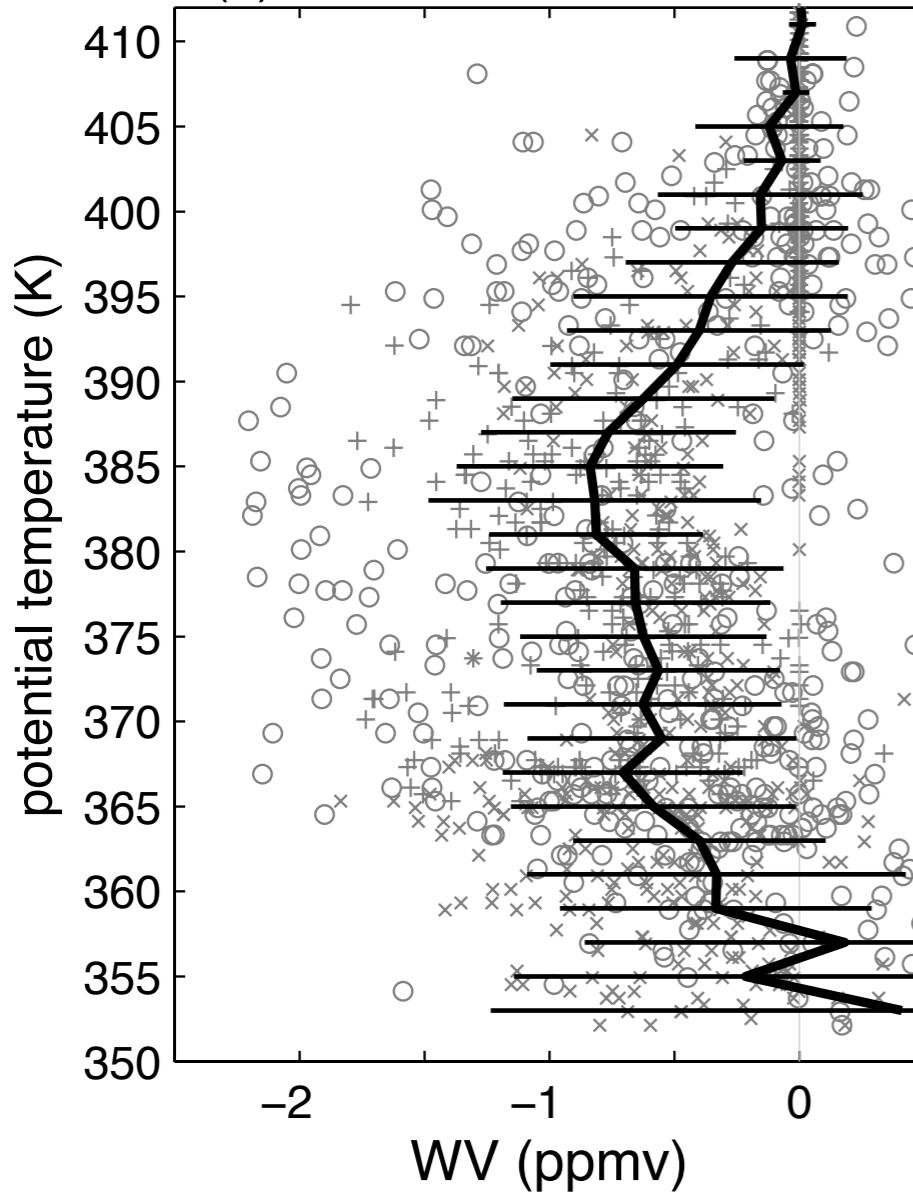


wave+micro

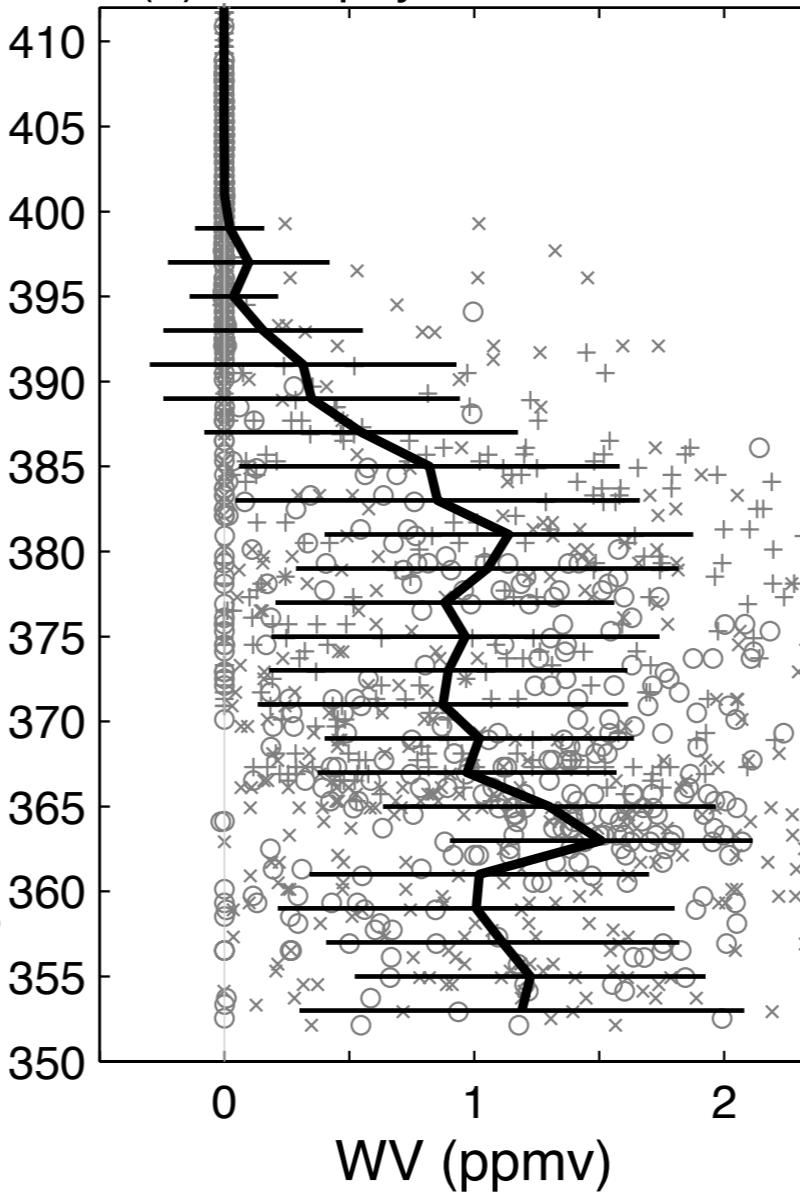


Impact on water vapor

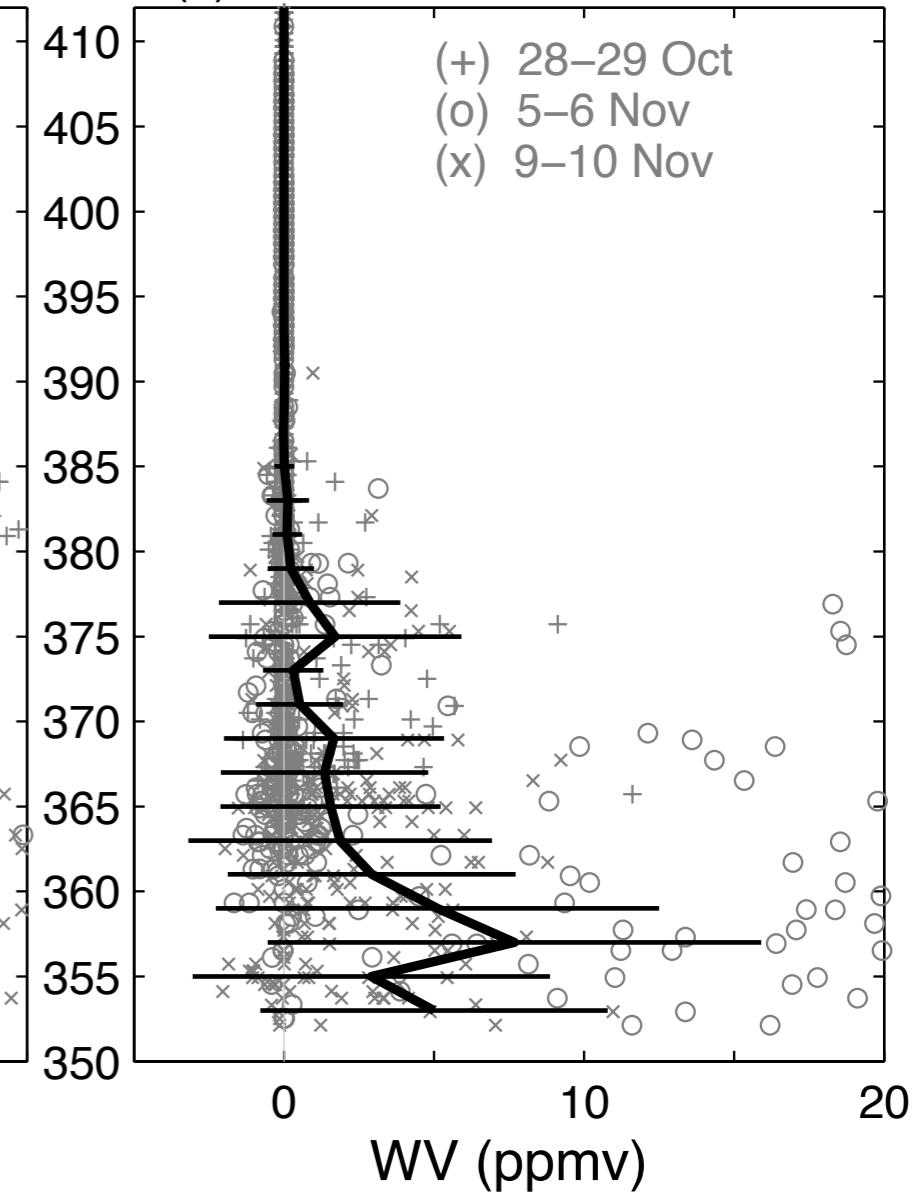
waves
-0.5 ppmv



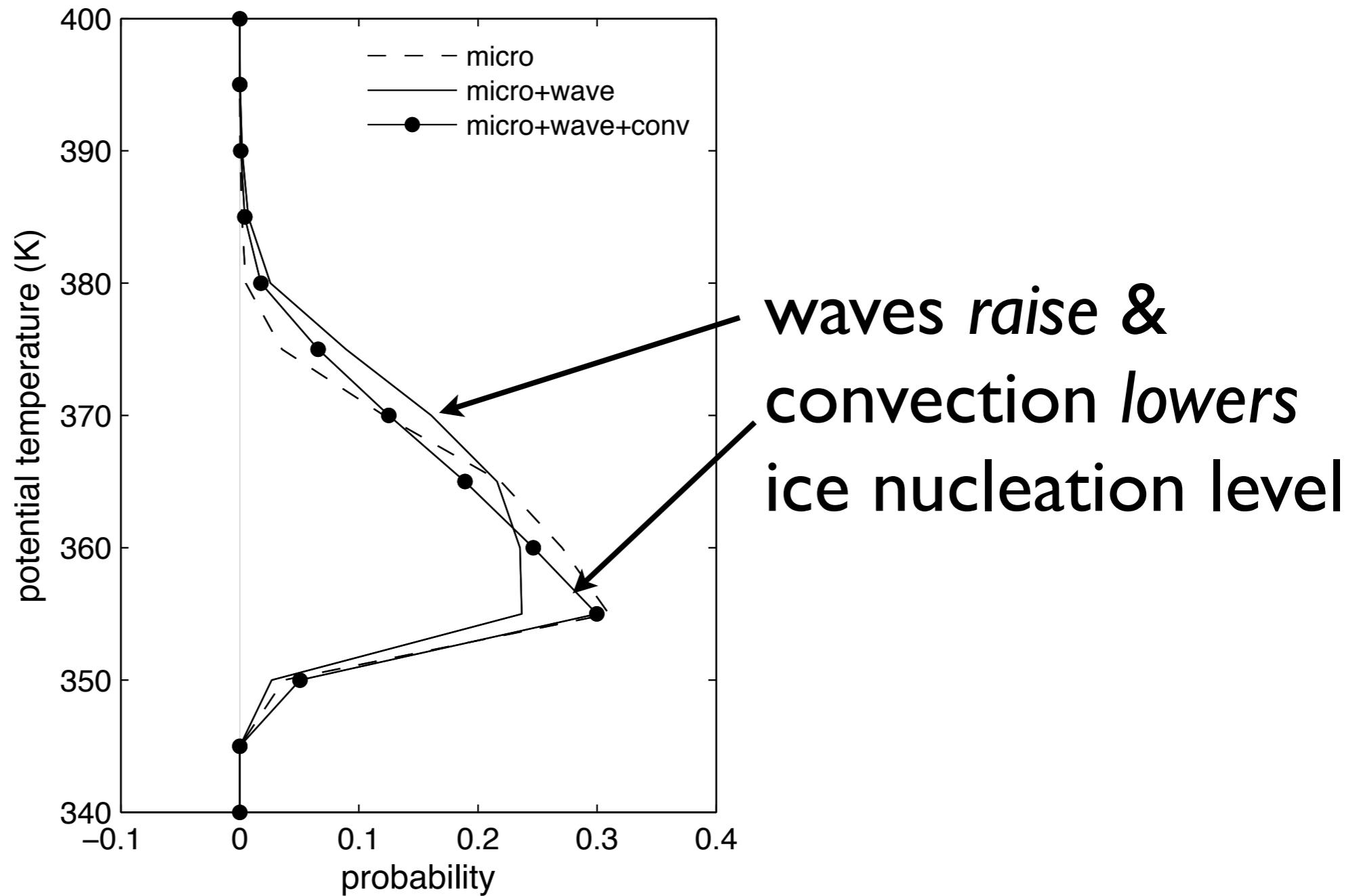
microphysics
+1 ppmv



convection
+1-5 ppmv



Frequency of ice nucleation as a function of height

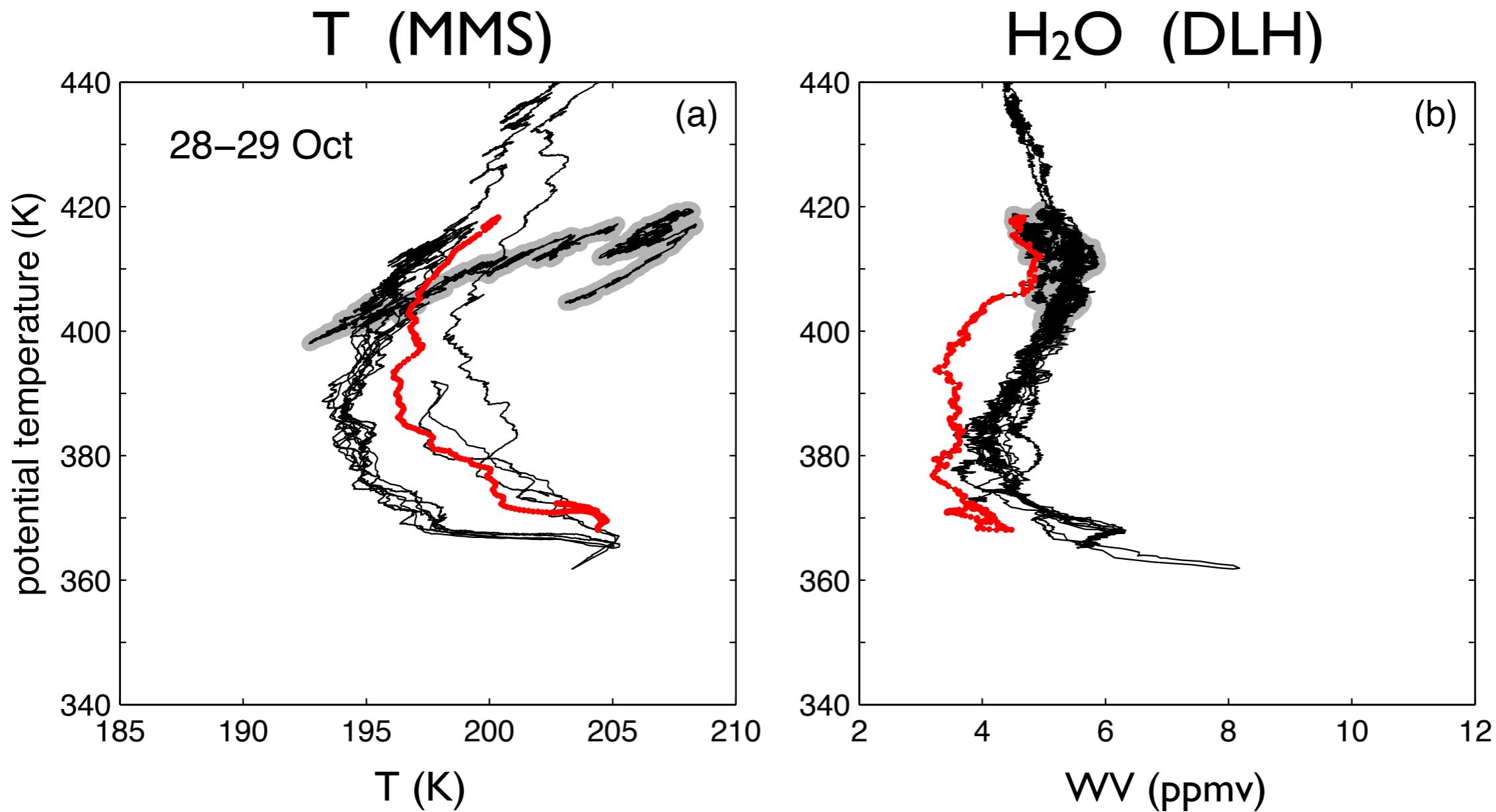


Summary

- Tropical cold point temperatures of the interpolated ERA-Interim reanalysis match those of MMS observations during Fall 2011 ATTREX deployment
- DLH water vapor mixing ratios are well simulated in model with waves, microphysics and convection
 - waves dehydrate (360-390 K level) ~ -0.5 ppmv
 - microphysics hydrate (350-380 K level) $\sim +1$ ppmv
 - convection hydrates (below 370 K level) $\sim +1-5$ ppmv

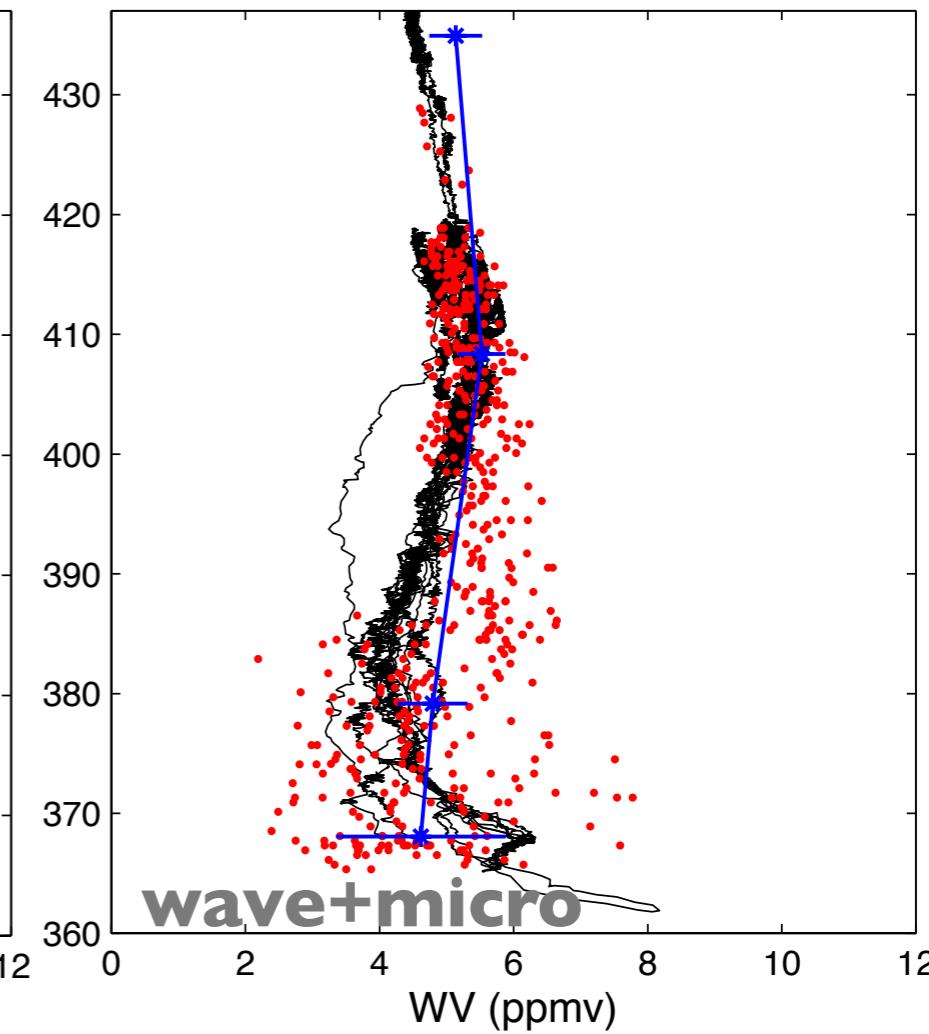
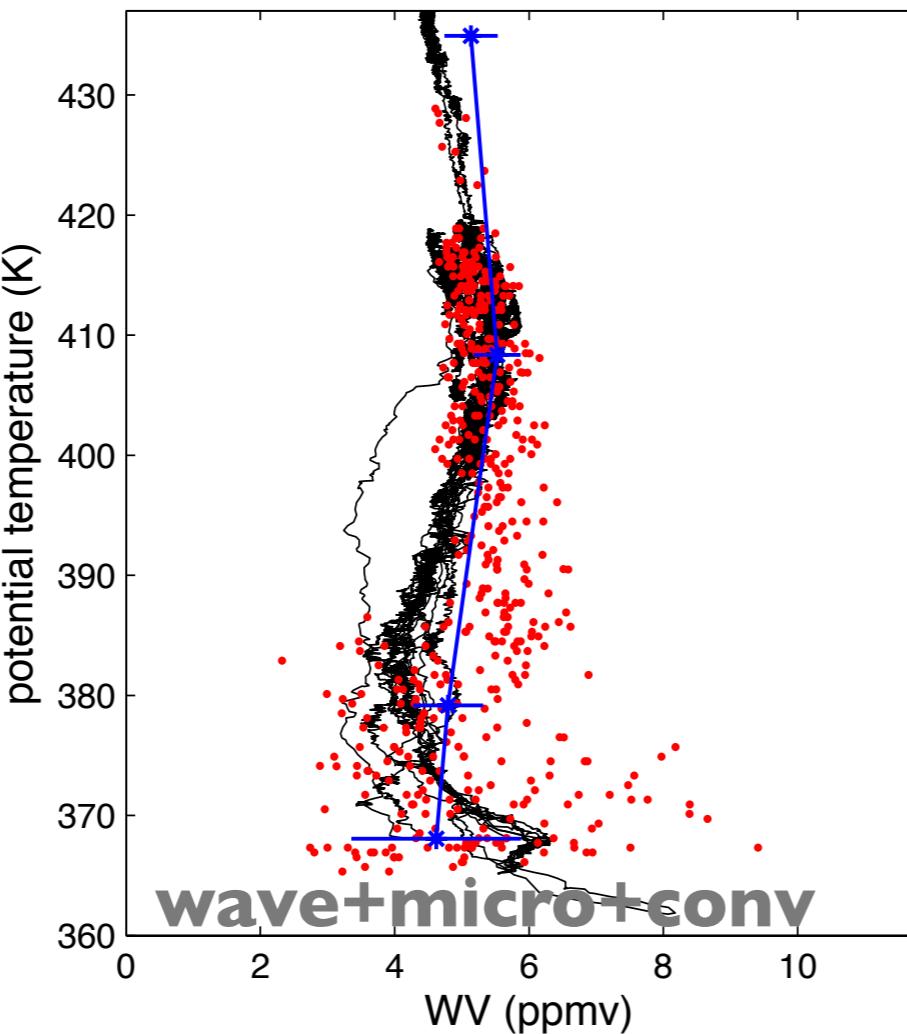
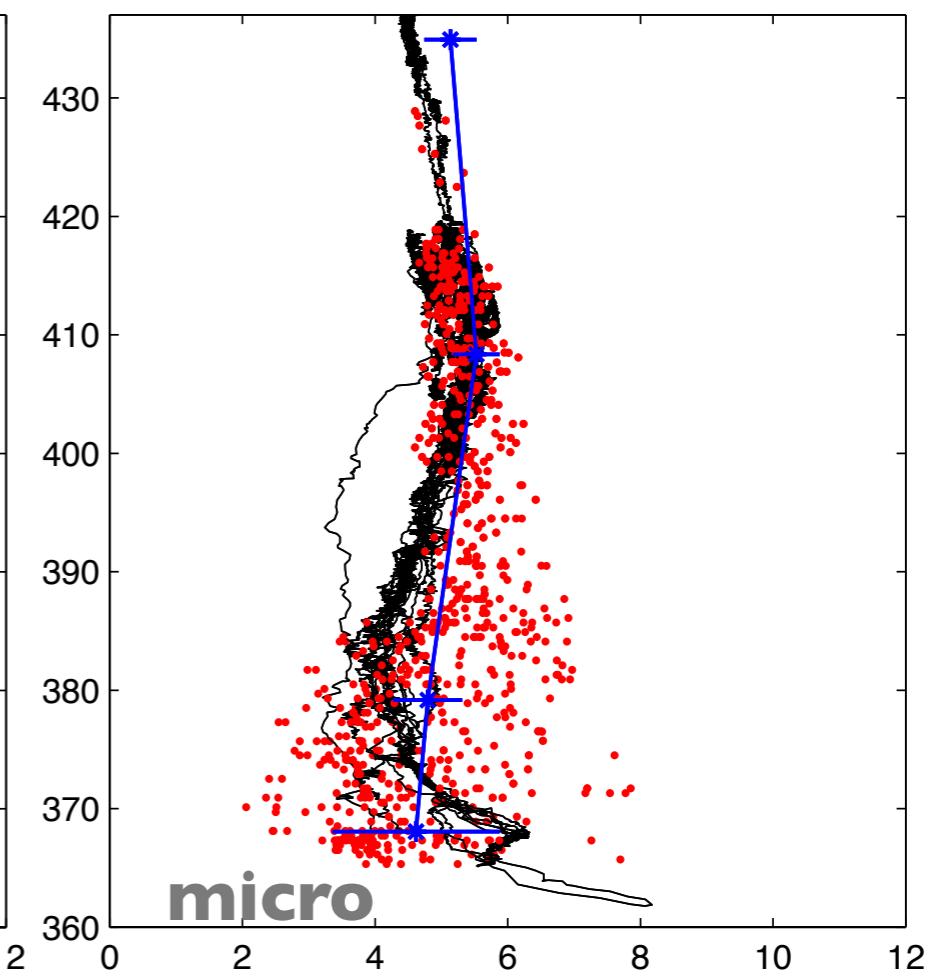
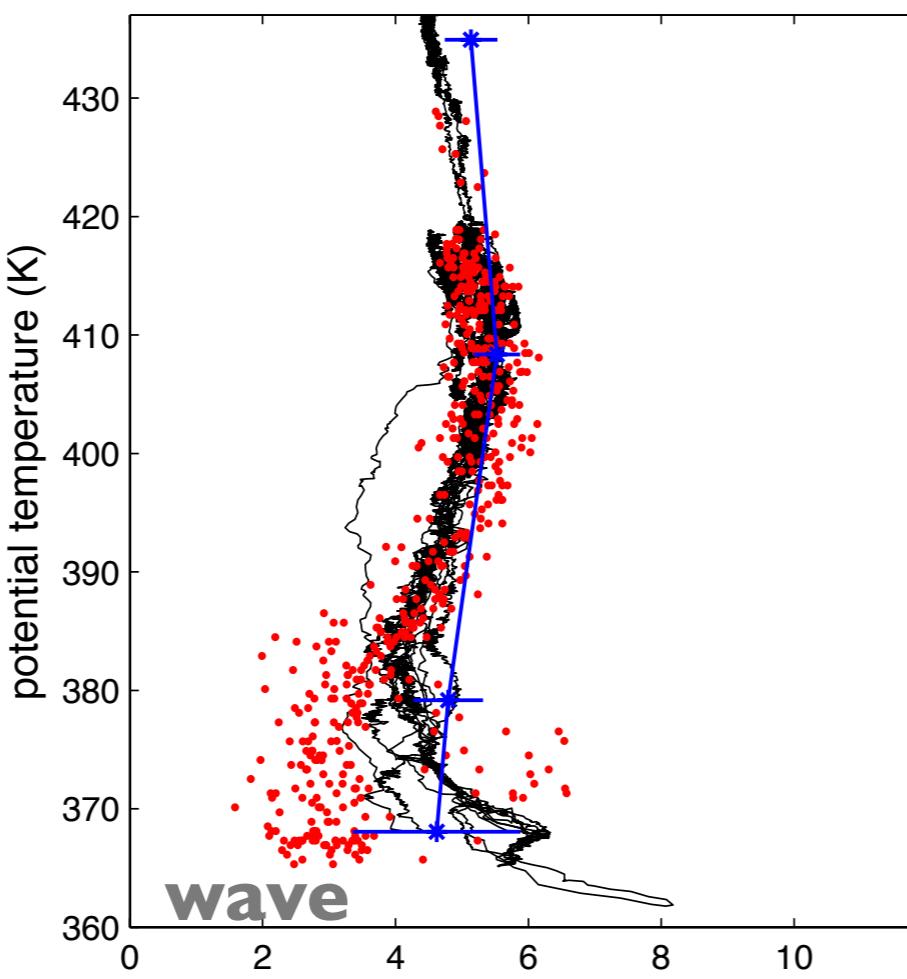
extra slides

28-29 Oct 2011 Flight

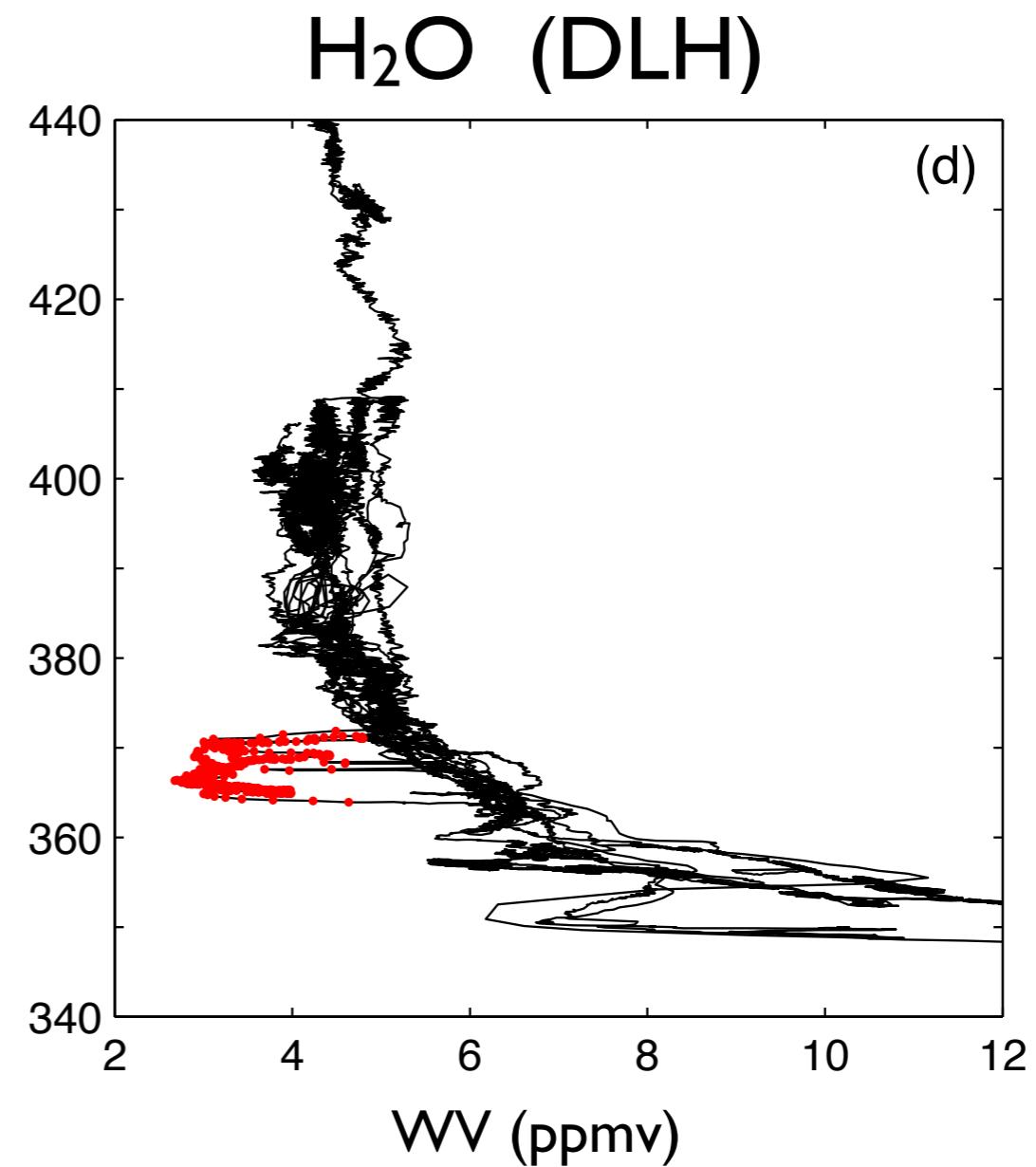
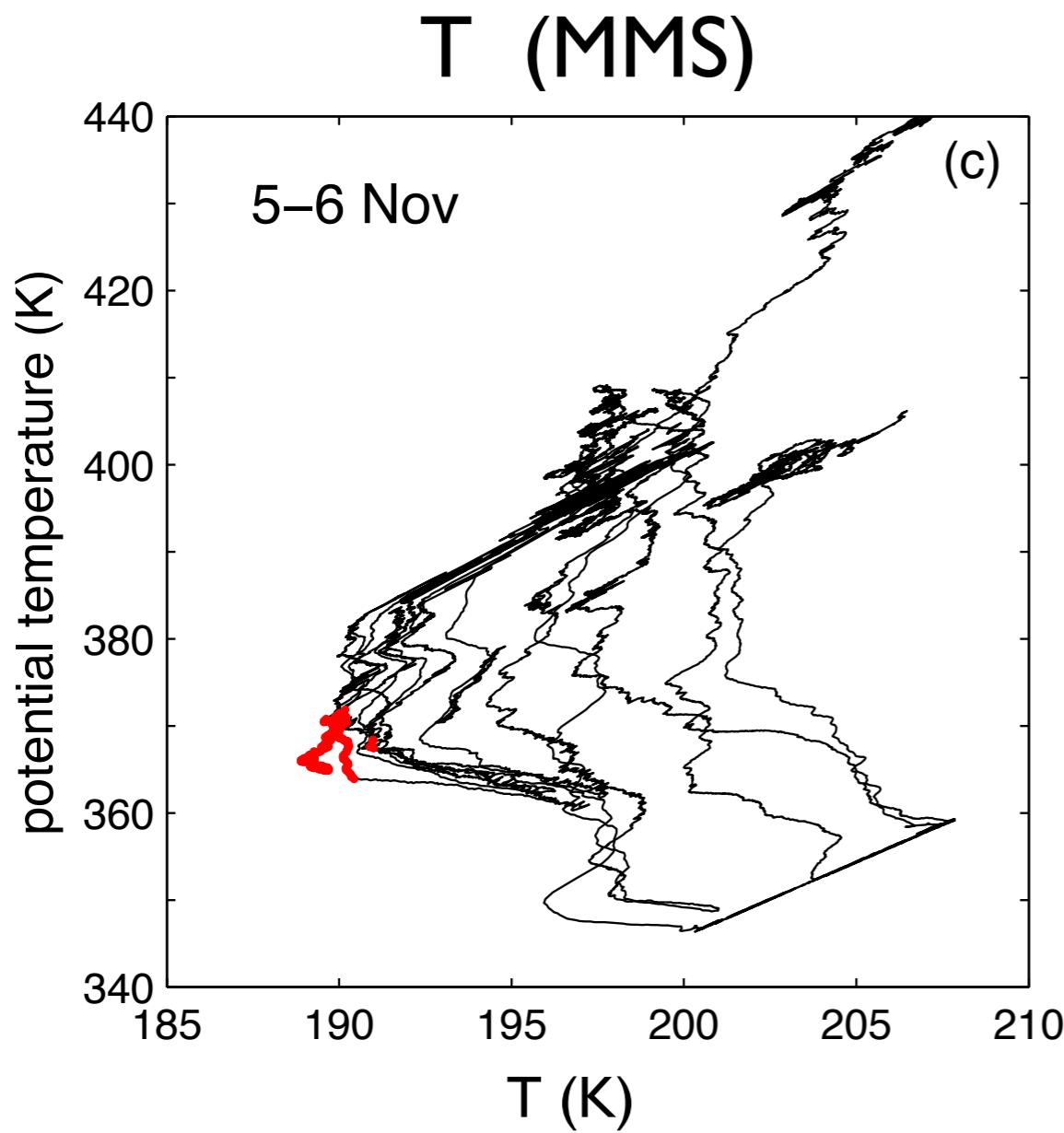


28-29 Oct

aircraft
MLS
model

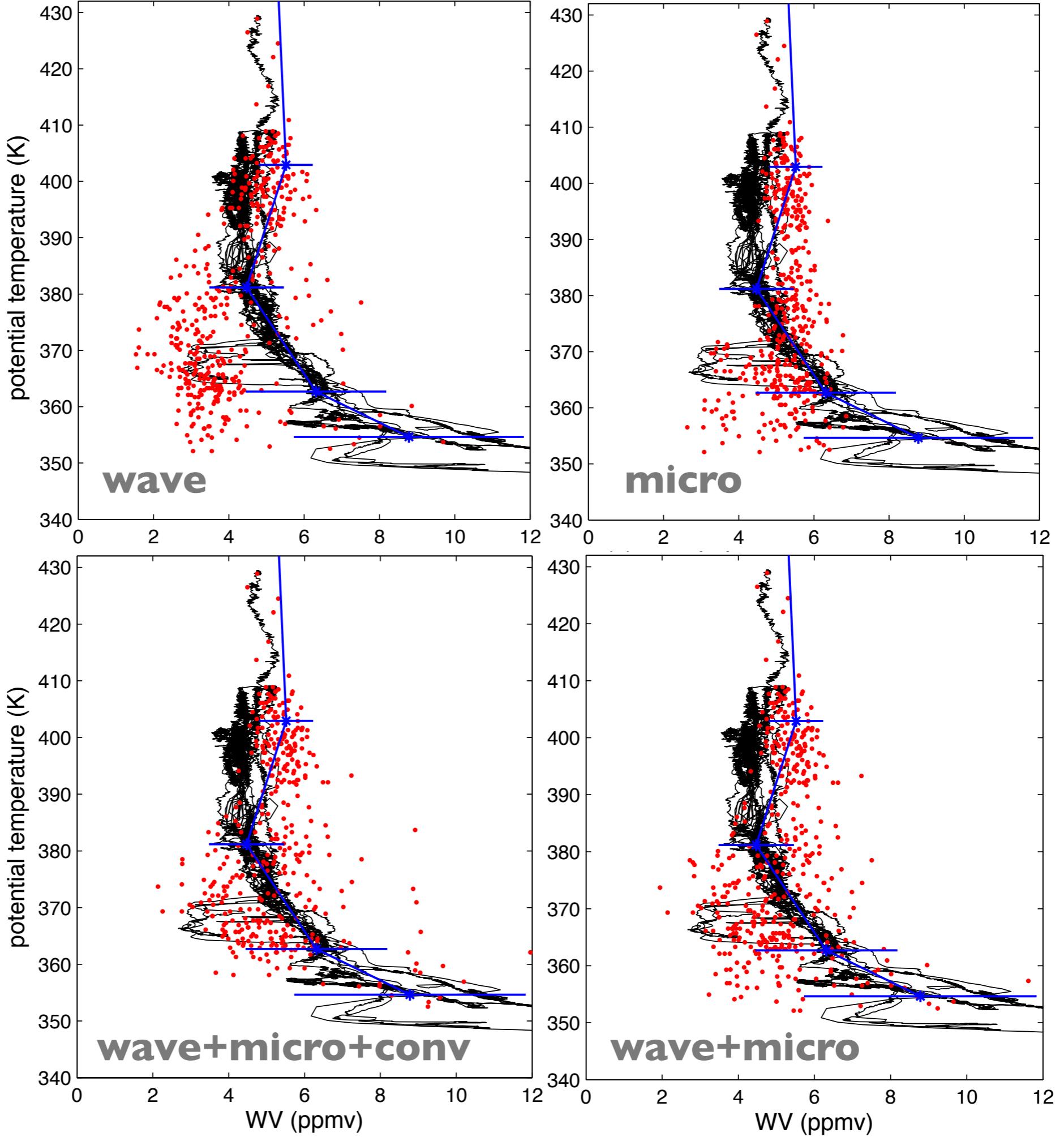


5-6 Nov 2011 Flight

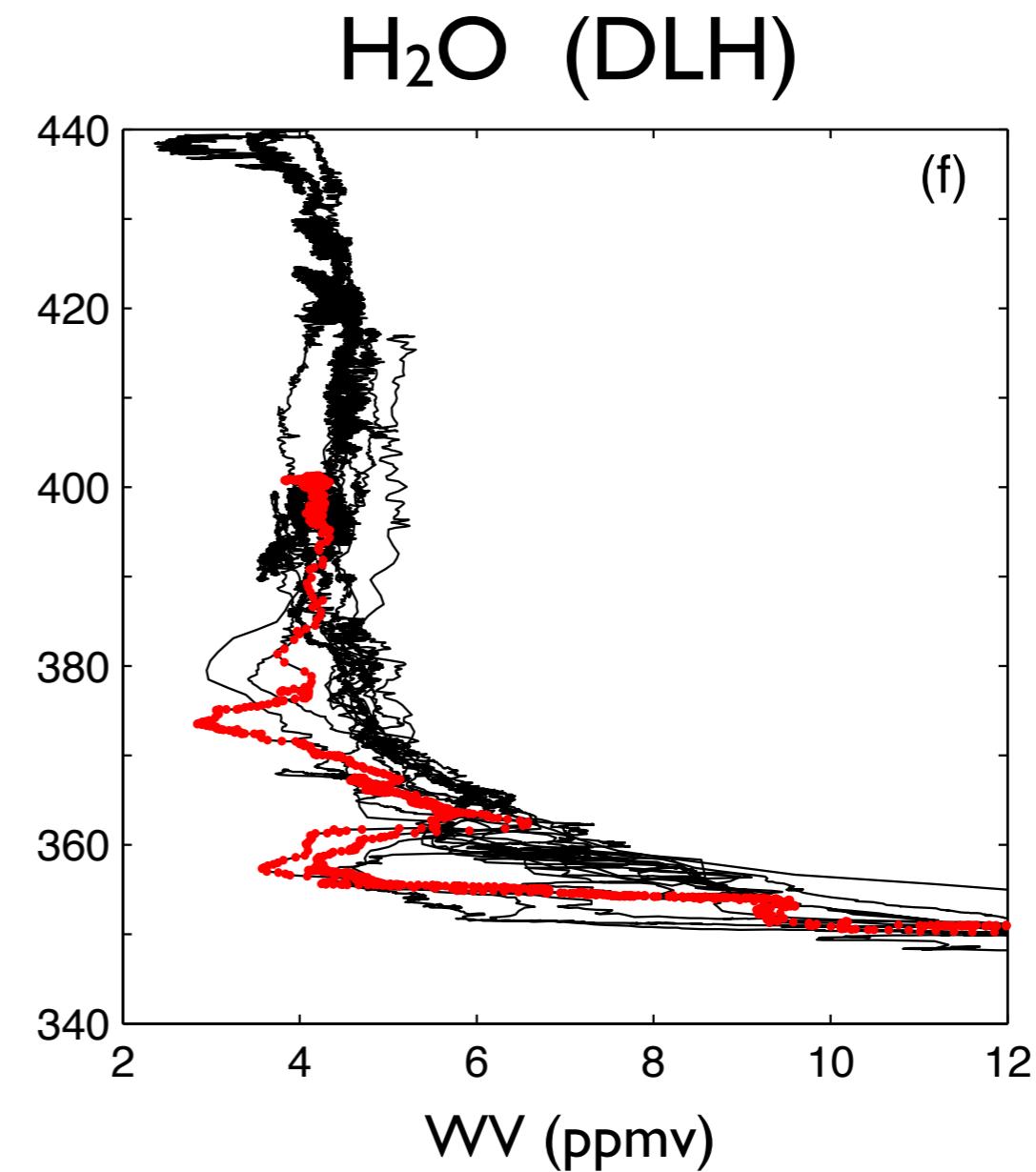
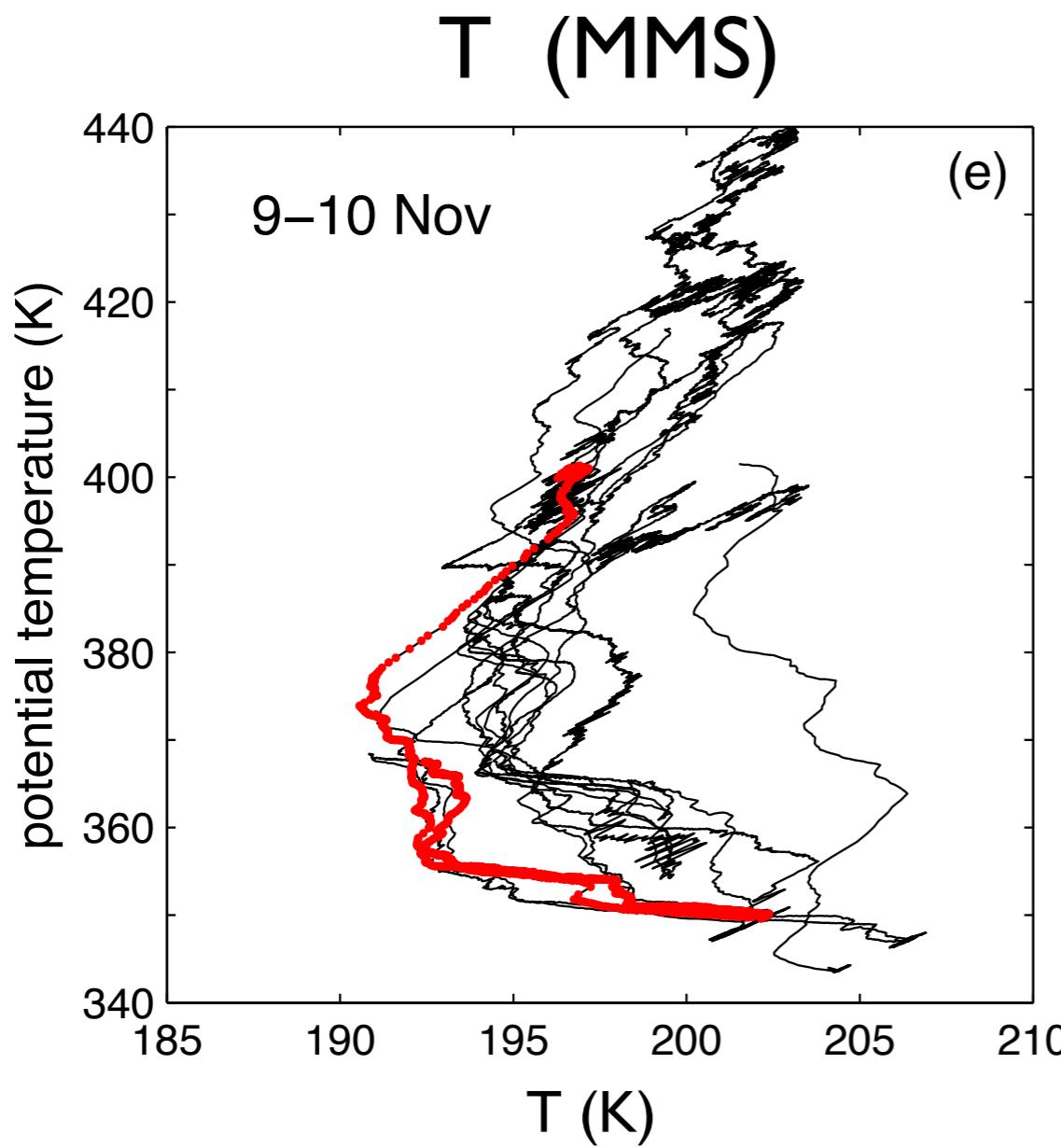


5-6 Nov

aircraft
MLS
model

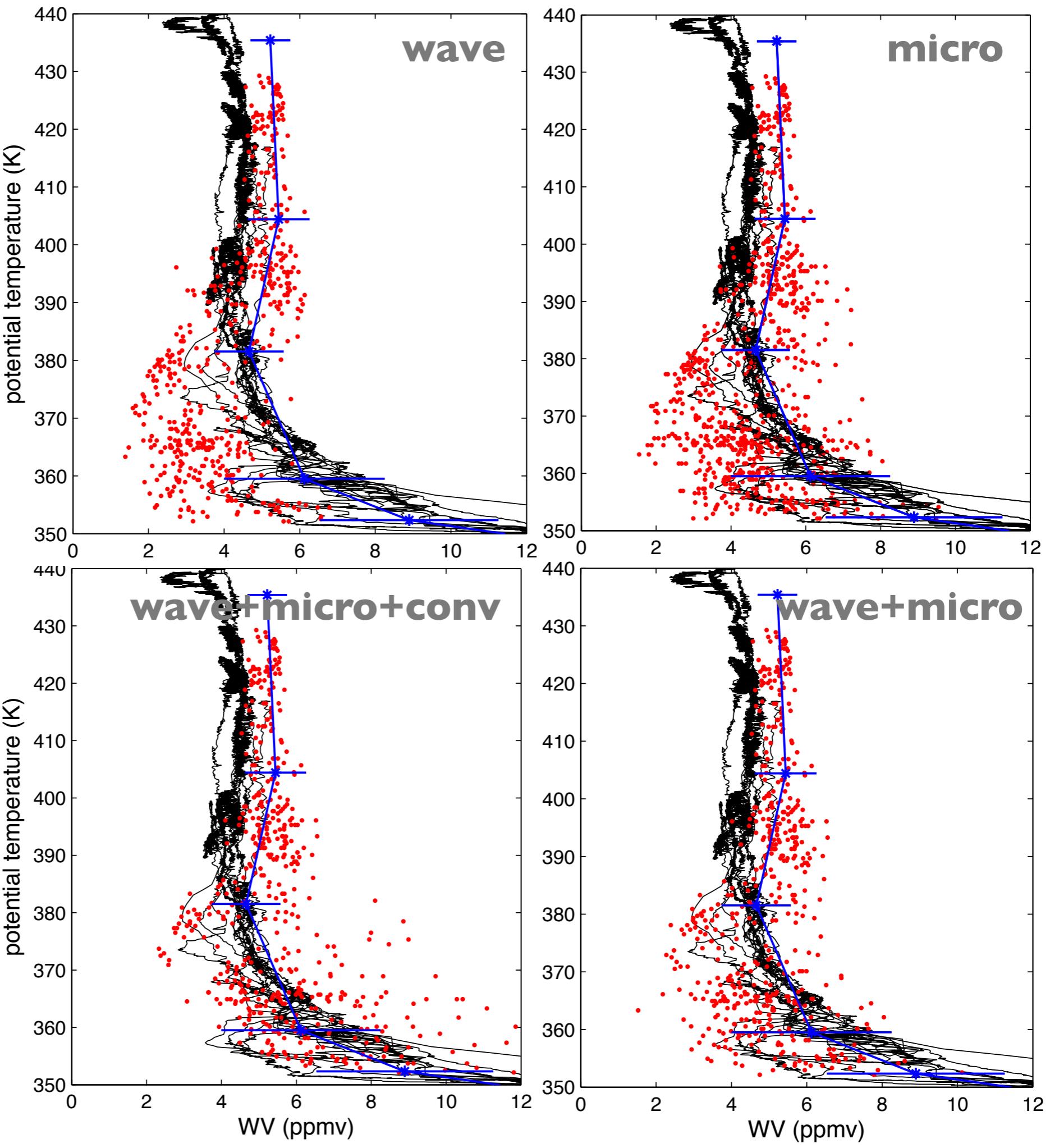


9-10 Nov 2011 Flight

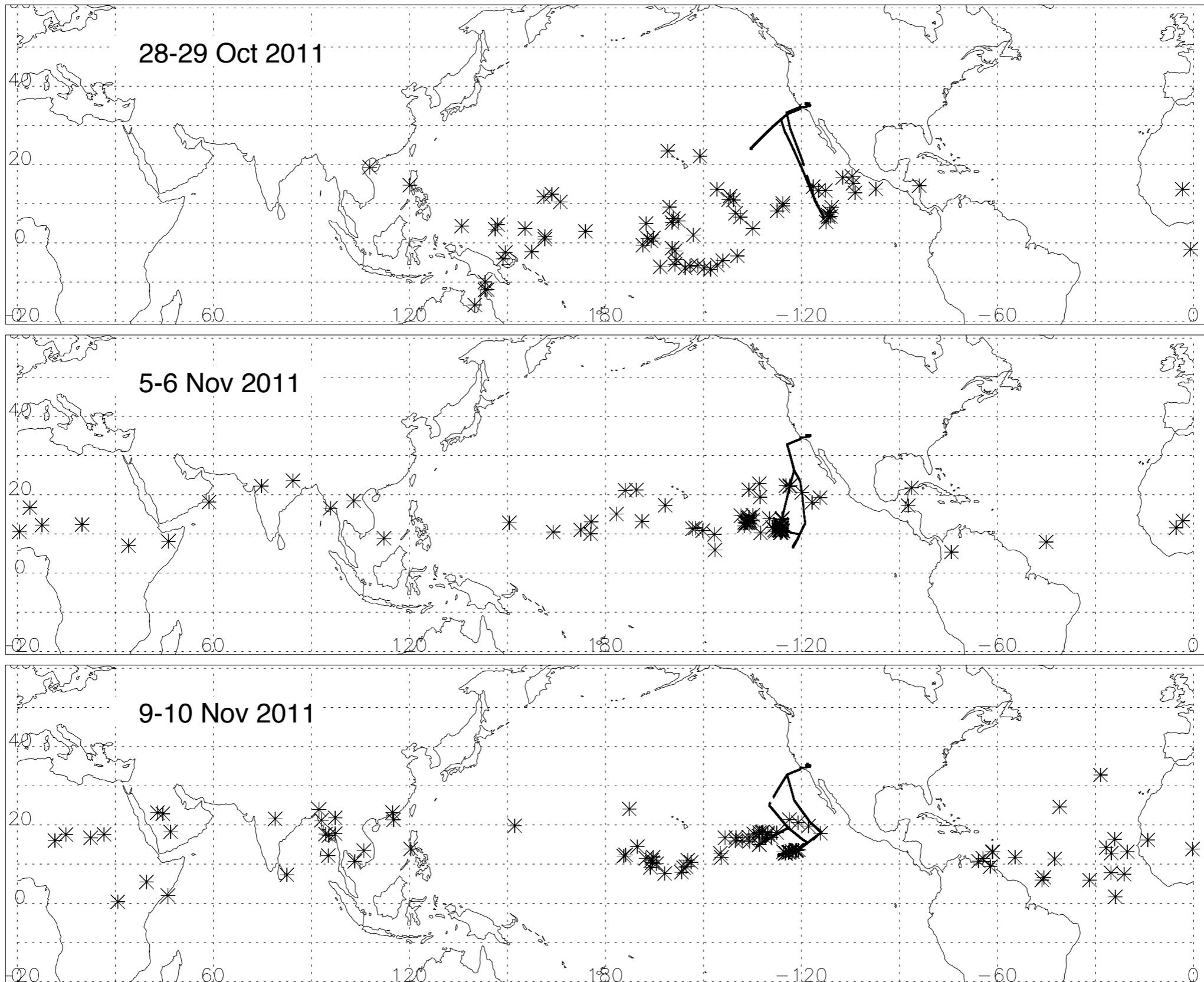


9-10 Nov

aircraft
MLS
model

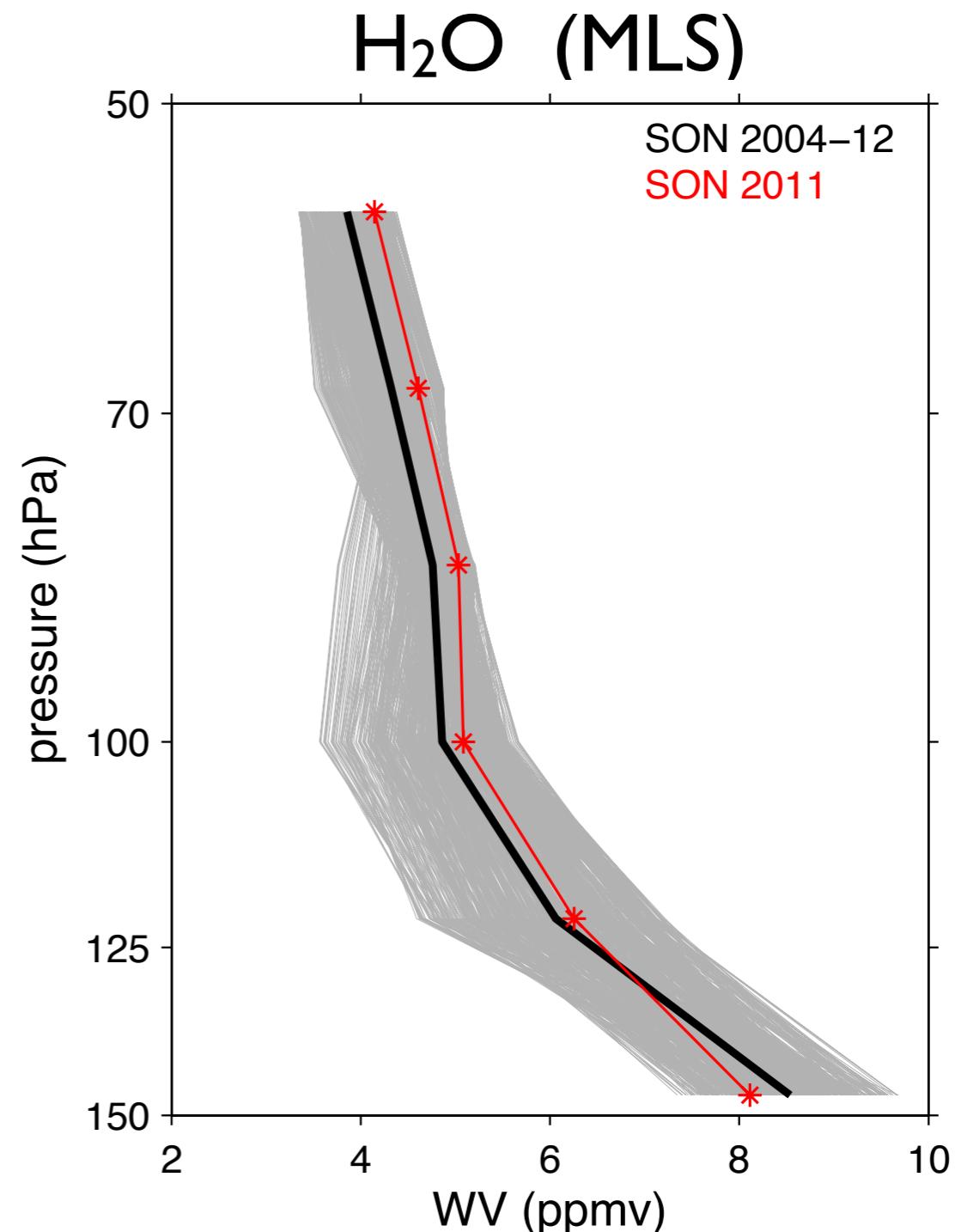
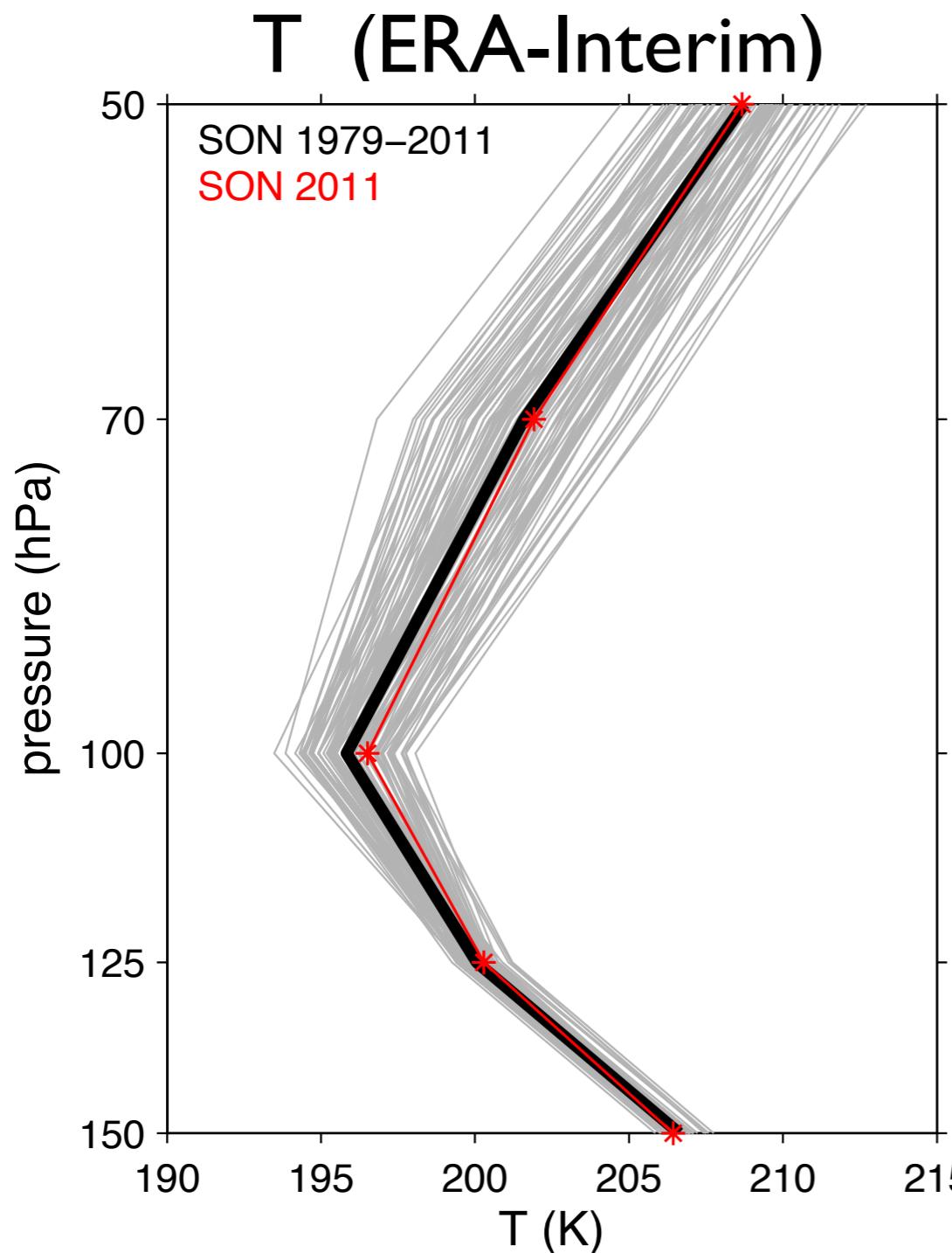


Locations of most recent ice at flight level

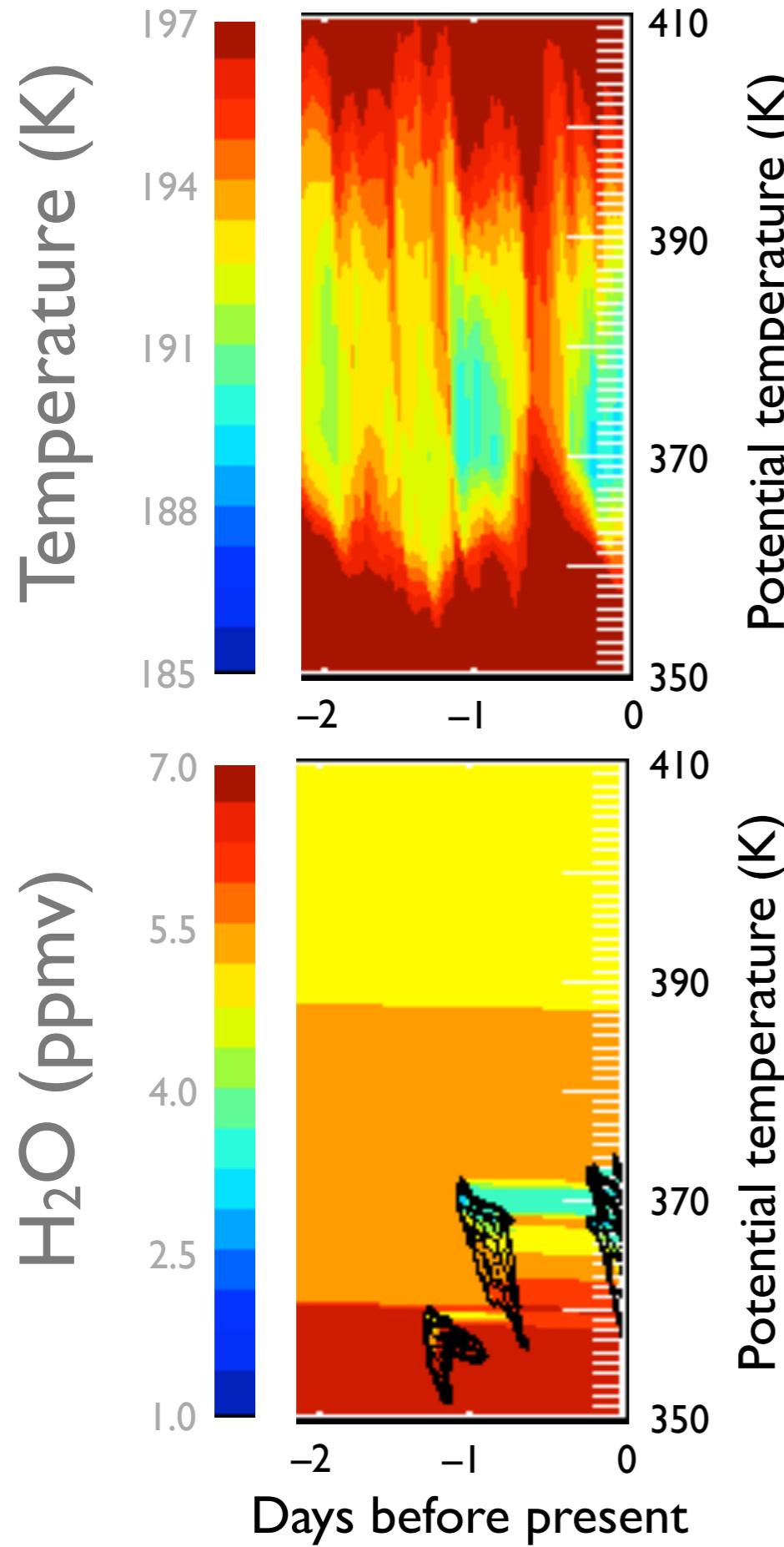


Temperature & H₂O

tropics (30°S-30°N) vertical structure



time-height curtains



simulated water vapor profile
on Day 0

